Shri Swami Vivekanand Shikshan Sanstha's

VIVEKANAND COLLEGE, KOLHAPUR

DEPARTMENT OF B. VOC. & COMMUNITY COLLEGE

VIVEKANAND COLLEGE, KOLHAPUR.
(AUTONOMOUS)

Board of Studies in Animation & Film Making

ANIMATION
& FILM MAKING

Syllabus

For

B. Voc Part - II

Advanced Diploma in Animation & Film Making

STRUCTURE OF SYLLABUS:

To be implemented from the academic year 2019-2020

1. Title of the course: BACHELOR OF VOCATION (Animation & Film Making)

A. INTRODUCTION

B. RATIONALE

C. COURSE OBJECTIVES

By studying animation & film making students will have a wider horizon in the field of art and will

- Students will complete an extensive body of amateur work as writer/directors.
- In addition to training as writer/directors, students will become proficient in other production and postproduction skills (camera, lighting sound, editing) and have the ability to enter careers in the entertainment industry, broadcasting, journalism, art, advertising, and arts management.
- Students will be able to apply theoretical, critical, and historical concepts when making style choices in their own projects and in referencing or analyzing the medium of cinema.
- Students will learn the rudiments of narrative filmmaking in the short form and be able to apply these skills to long-form work.
- Students will learn the fundamentals of documentary filmmaking and forms-direct cinema, cinema verite, re-enactment, the documentary essay, the place film, diary forms-and the documentary of systems and abstract processes-finance, globalization, and the environment. Young people have a healthy sense of outrage; they are inspired by the greater good.
- Students will engage in the use and analysis of emerging technologies.
- Students will be able to research, gather, and synthesize information.
- Students will demonstrate the ability to depart from traditional or comfortable ways of thinking, to explore, to wander, to get lost, to journey down unfamiliar channels and emerge with renewed perceptions in order to innovate and add to cinematic practice.

THE STUDENTS WILL LEARN:

- Students will demonstrate that the critical study of cinema inform their filmmaking and that the study and practice of film production enhance their work as film scholars and analysts.
- Students will demonstrate that they understand the pre-production, production, and postproduction filmmaking process
- Students will demonstrate the relationship between film form and aesthetic effect through both film analysis and the creation of motion pictures.
- Students will be able to conduct film research and compose cogent, persuasive, and valid essays about film.

- Students will demonstrate a broad knowledge of film history, national cinemas and models of production.
- Recognize and evaluate critical and aesthetic issues within computer graphics and the mixed media. (Issues)
- Apply aesthetic judgments and critical thinking skills to art and graphics related issue. (Aesthetics)
- Demonstrate mastery of specific technical, conceptual and critical abilities within computer graphics and the mixed media. (Abilities)
- Demonstrate proficiency with industrial applications to visual communication related technologies. (Proficiency)
- Communicate effectively in written format on research and creative issues. (Written)
- Communicate effectively in oral format on research and creative issues. (Oral)
- Apply critical thinking and aesthetic judgments in critiquing mixed media and computer graphics productions. (Critiquing)
- Function on multi-disciplinary teams. (Teams)
- Work collaboratively and individually with an understanding of the production process utilized in industry-standard studios. (Process)
- Demonstrate professionalism through creative and intellectual independence. (Professionalism)

2. Duration:

The duration of the B.Voc. Course will be of **three years.**

- **B.Voc. Part I - Diploma in Animation & Film Making**
- **B.Voc. Part II - Advanced Diploma in Animation & Film Making**
- **B.Voc. Part III - Bachelor of Vocation in Animation & Film Making**

The final B.Voc degree will be awarded only after completion of three year course. The suggested credits for each of the years are as follows:

Year	**Awards**	**Normal calendar duration**	**Skill Component Credits**	**General Education Credits**
1	**Diploma in Animation & Film Making**	Two Semesters	36	24
2	**Advanced Diploma in Animation & Film Making**	Four Semesters	36	24
3	**B.Voc in Animation & Film Making**	Six Semesters	36	24
			TOTAL	**108**

General Education Component should not exceed 40% of the total curriculum.

Credits can be defined as the workload of a student in

1. Lectures
2. Practicals
3. Seminars
4. Private work in the Library/home
5. Examination
6. Other assessment activities.

The following formula should be used for conversion of time into credit hours.

a) One Credit would mean equivalent of 15 periods of 60 minutes each, for theory, workshops /labs and tutorials;

b) For internship/field work, the credit weightage for equivalent hours shall be 50% of that for lectures/workshops;

c) For self-learning, based on e-content or otherwise, the credit weightage for equivalent hours of study should be 50% or less of that for lectures/workshops.

3. Eligibility:

The eligibility condition for admission to B.Voc. programme shall be 10+2 or equivalent, in any stream from any recognized board or university.

4. Medium of Instruction:

The medium of instruction of the course will be **Marathi / English**

5. Pattern: Choice based Credit System (CBCS) Semester Pattern.

6. Examination:

A. Scheme of examination:

- The semester examination will be conducted at the end of each term (both theory and practical examination)
- Theory paper will be of 50 marks each. The practical examination will be of 200 marks and industrial practical training/project work is of 50 marks.
- Question papers will be set in the view of the entire syllabus and preferably covering each unit of the syllabus.

For each semester there will be four theory papers. Practical Examination will be conducted at the end of every semester.

Paper Number	Title of Paper (For Semester III)	Total Marks
I	Fundamentals Of Financial Accountings -I	40+10 = 50
II	Principals of Animation	40+10 = 50
III	Clay Animation	40+10 = 50
IV	3D Modelling & Texturing	40+10 = 50
	TOTAL	**200**

The practical examination will be of 200 marks.

Sr. No.	Practical examination	Marks	Internal Assessment	Marks
1	Practical	180	Projects/ Industry Visit	50
2	Portfolio	20		
	Total	**200**		50

The total weightage of first term is of 450 marks, the details of which are-

Sr. No.	Title	Marks
1	Theory Examination 50 X 4	200
2	Practical Examination.	200
3	Internal Assessment	50
	TOTAL	**450**

B. Nature of question paper:

For the **papers II, III and IV** there will be in all **SEVEN** questions in each paper of which any **FIVE** should be solved. All questions will carry equal marks i.e. each question will be of 10 marks.

General nature of the question paper will be:

Question Number	**Type**	
Q.1	Short answer	Any two out of three
Q.2,3,4,5,6	Long answer	No internal options.
Q.7	Short notes	Any two out of three

C. Standard of Passing:

To pass the examination a candidate must obtain at least 35% i.e 14 marks out of 40 for theory examination and 4 marks out of 10 in internal assessment of each paper. Total minimum 14 marks out of 50 for each paper should be obtained.

For practical examination minimum 50% marks should be obtained.

The result will be declared on the basis of theory and practical examination for each semester during the course.

D. External Students: Not applicable as this is a practical oriented course**.**

7. University Term: As per academic calendar of the university.

For the second year i.e. Advanced Diploma in Animation & Film Making practical examination and theory paper assessment will be done at college level.

8. List of equipment and instruments:

1. Computer Machines
2. Colour Printer
3. Scanner
4. Digital Camera
5. Projector
6. Internet Connectivity
7. CCTV Camera for Animation Laboratory is must.

9. Laboratory Safety Equipments:

Part I: Personal Precautions:

1. Must wear **Lab Aprons / Lab Jacket** and proper shoes.
2. Except in emergency, **over-hurried activities** are forbidden.
3. **Eating, Drinking and Smoking** in the laboratories is strictly forbidden.
4. **Mobile phones, external hard drives, pen drives are not allowed.**

Part II: Use of Safety and Emergency Equipments:

1. First aid Kits
2. Fire extinguishers (dry chemical and carbon dioxide extinguishers)
3. Management of Local exhaust systems.
4. Sign in register if using instruments.

10. Workload:

Each skill based paper (i.e. Paper no. II, III and IV) will have **four theory** periods per week. There are **four practical** per week. Each practical will be of four periods. The practical batch will have maximum 20 students.

The total workload for one batch will be:

1. **One Paper** on General Education:	=	06 Theory Periods.
2. **Three Papers** on skill based Education: 3 X 4	=	12 Theory Periods.
3. **Four Practical** work per week: 4 X 4	=	16 Practical periods.
4. **Project Work** per batch per week:	=	02 Periods

	TOTAL	**36 Periods.**

Working hours will be 5 hours (300 minutes) per day i.e. six periods each of 50 minutes.

11. MEMORANDUM OF UNDERSTANDING (MOU):

The purpose of this MOU is to clearly identify the roles and responsibilities of each party (i.e. college and industry partner) as they relate to the implementation of the **B.Voc. Programme in Animation & Film Making** at the college.

It is recommended to sign at least **FIVE MOUs** with the industry partners in the related field.

B.Voc. Part - II (Advanced Diploma in Animation & Film Making) Course structure

General Structure:

The diploma course has two semesters, each of 450 marks. There will be **four theory** papers for each semester of 50 marks each.

1) Paper-I: English for Business Communication - Theory 40 Marks + Internal 10 Marks.

2) Paper-II: - Theory 40 Marks + Internal 10 Marks.

3) Paper-III: - Theory 40 Marks + Internal 10 Marks.

3) Paper-IV: - Theory 40 Marks + Internal 10 Marks.

There will be practical examination for each semester. The duration of practical examination will be of six hours and it will be of 100 marks of which 20 marks are reserved for Portfolio. The internal assessment includes industry training via internships, handling live projects, visits to Advertising Agency and Graphic Design Studios etc.

SYLLABUS
N. B.

(i) Figures shown in bracket indicate the total lectures required for the respective units.
(ii) The question paper should cover the entire syllabus. Marks allotted to questions should be in proportion to the lectures allotted to respective to units.
(iii) All units should be dealt with S.I. units.
(iv) Project / Industrial visit per semester is compulsory.
(v) Use of recent editions of reference books is essential.
(vi) Use of Output Devise allowed.

12. Program Outcomes (POs)

1. B. Voc. Graduates in Animation & Film making will demonstrate the critical study of cinema inform their filmmaking and that the study and practice of film production enhance their work as film scholars analysts.
2. B. Voc. Graduates in Animation & Film making will Computer Animation and Game Development graduates will have an understanding of critical and aesthetic issues in computer graphics and mixed-media.
3. B. Voc. Graduates in Animation & Film making will access industry related learning resources.
4. B. Voc. Graduates in Animation & film making will create effective visual animations using the elements of story.
5. B. Voc. Graduates in Animation & film making will identify and apply the 12 principles of animation. List of films featuring clay animation
6. B. Voc. Graduates in Animation & Film making will relate some knowledge of the history of animation.
7. B. Voc. Graduates in Animation & film making will demonstrate entry-level workplace computer competencies using industry standard 2D & 3D animation software.
8. B. Voc. Graduates in Animation & film making will demonstrate industry professional standards within their attitudes, conduct, ethics and work.
9. B. Voc. Graduates in Animation & film making will design layouts and backgrounds that incorporate principles of composition, perspective and color, with speed accuracy and dexterity, using a variety of media.

Program Educational Outcomes:

1. The graduates will demonstrate that they understand the pre- production , production and post production filmmaking process.
2. The Graduates will produce a finished digital interactive portfolio visually demonstrating, animation storytelling, and technical skills.

Program Specific Outcomes:

1. B. Voc. Graduates in Animation & film making will demonstrate mastery of specific technical, conceptual and critical abilities within computer graphics and the mixed media.
2. B. Voc. Graduates in Animation & film making will create 2D and 3D characters and environments that reflect the integration of graphic clarity, design principles, performance principles and theoretical constructs.

SEMESTER III

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GENERAL EDUCATION:

Paper I: FUNDAMENTALS OF FINANCIAL ACCOUNTING-I

Work Load - 6		Total Marks – 50
Theory – 4 Lectures / Week Practical- 2 Lectures / Week		Theory- 40 Practical- 10

Course Objectives:

1. To impart basic accounting knowledge as applicable to business.
2. To help students understand fundamental accounting concepts and principles.
3. To introduce students to accounting, stressing its importance in today's business world
4. To provide students with a theoretical basis upon which they will develop their knowledge in other areas of accounting

Course Outcomes (COs):

Course Outcomes(COs): Upon completion of this course, students will be able to		Mapping with PO's
CF201.1	Perform the basic accounting functions.	3,8
CF201.2	Perform the journal entries and leaguer accounts.	3,8
CF201.3	Use various meaning methods effectively.	3,8
CF201.4	Prepare Final Accounts of Sole Traders and partnership firms.	3,8

Correlation matrix of Course outcomes with Programmed outcomes (CO-PO)
1=Low correlation, 2=Medium correlation, 3=High correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2
CF210.1	-	-	1	-	-	-	-	2	-	-	-
CF210.2	-	-	1	-	-	-	-	2	-	-	-
CF210.3	-	-	1	-	-	-	-	2	-	-	-
CF210.4	-	-	1	-	-	-	-	2	-	-	-

Course contents:

Unit I : **Introduction to Accounting**

Meaning, Nature and Advantages of Accounting, Branches of Accounting, Accounting Concepts and Conventions, Types of Accounts, Rules of journalizing, Source Documents – Cash Voucher, Petty Cash Voucher, Cash Memo – Receipts, Debit Notes, Credit Note, Paying Slips, Withdrawals, Cheque

Unit II : Journal and Ledger

Preparation of Journal entries and Ledger accounts – Subsidiary Books - Purchase Book, Purchase Return Book, Sales Book, Sales Return Book, Cash Book, Bills Receivable Book, Bills Payable Book, Journal Proper

Unit III : Depreciation

Meaning, Methods – Straight Line Method – Reducing Balance Method, Change in Depreciation Method.

Unit IV: Final Accounts

Preparation of Trial Balance, Preparation of Final Accounts of Sole Traders and partnership firms

Practical:

1) Preparation of Journal entries and Ledger accounts
2) Preparation of subsidiary books
3) Preparation of Trial Balance
4) Practical problems on Final Accounts of sole traders and partnership firms
5) Practical problems on methods of depreciation

Scheme of Internal Practical Evaluation **10 Marks**

1) Submission of Record Book 5 Marks
2) Viva – Voce 5 Marks

Text Books/Reference Books/ Other Books/E-material/Paper

Sr. No	Title	Author	Publisher	Edition	Year of Edition
1	Advanced Accountancy	M.C. Shukla and T.S. Garewal			
2	Advanced Accountancy	S.C. Jain and K. L. Narang			
3	Advanced Accountancy	S.M. Shukla.			
4	Advanced Accountancy	S. N. Maheshwari.			
5	Advanced Accountancy	R. L. Gupta.			

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Paper –II: Principal of Animation 50Hrs

Course Type: Theory / Practical	Theory
Required/Elective	Required
Prerequisite	Fundamentals of art & Classic Animation
Teaching Scheme (Lecture/Practical/Tutorial/Drawing)	02/02/00/00 Hours
Total contact Hours (Lecture/Practical/Tutorial/Drawing)	50/00/00/00 Hours
EvaluationScheme: Theory Theory Paper /Term Work/Oral/Practical	--/--/--/--

Course Outcomes(COs): Upon completion of this course, students will be able to		Mapping with PO's
CO107.1	students will be able to successfully execute the "Principles of Animation."	5
CO107.2	Apply action analysis and observations to animated drawings.	4
CO107.3	Apply critical thinking skills elemental to the problem solving of design and the visual arts.	4
CO107.4	Create drawings that convey action in terms of movement, emotion, attitude, and expression.	5
CO107.5	Students will be able to render fluid "arc" movements for a falling leaf.	5
CO107.6	Students will be able to render fluid "squash and stretch" movements for a bouncing ball.	5

Correlation matrix of Course outcomes with Programmed outcomes (CO-PO)
1=Low correlation, 2=Medium correlation, 3=High correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2
CO107.1	-	-	-	-	3	-	-	-	-	-	2
CO107.2	-	-	-	-	2	-	-	-	-	-	2
CO107.3	-	-	-	-	3	-	-	-	-	-	2
CO107.4	-	-	-	-	3	-	-	-	-	-	2
CO107.5	-	-	-	-	3	-	-	-	-	-	2
CO107.6	-	-	-	-	3	-	-	-	-	-	2

The 12 Principles of Animation

Squash and Stretch

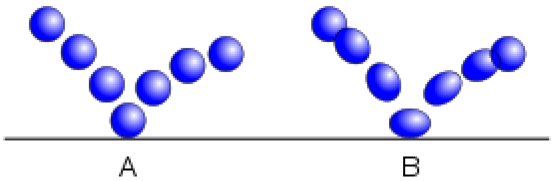
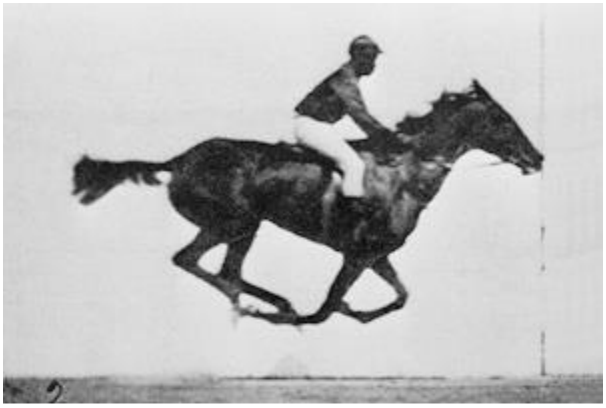


Illustration of the "squash and stretch"-principle:
Example **A** shows a ball bouncing with a rigid, non-dynamic movement. In example **B** the ball is "squashed" at impact, and "stretched" during fall and rebound. The movement also accelerates during the fall, and slows down towards the apex (see "slow in and slow out").



Animated sequence of a race horse galloping. Photos taken by Eadweard Muybridge. The horse's body demonstrates squash and stretch in natural musculature.

The most important principle is "squash and stretch",[4] the purpose of which is to give a sense of weight and flexibility to drawn objects. It can be applied to simple objects, like a bouncing ball, or more complex constructions, like the musculature of a human face.[5][6] Taken to an extreme point, a figure stretched or squashed to an exaggerated degree can have a comical effect.[7] In realistic animation, however, the most important aspect of this principle is the fact that an object's volume *does not* change when squashed or stretched. If the length of a ball is stretched vertically, its width (in three dimensions, also its depth) needs to contract correspondingly horizontally.[8]

Anticipation

Anticipation is used to prepare the audience for an action, and to make the action appear more realistic.[9] A dancer jumping off the floor has to bend the knees first; a golfer making a swing has to swing the club back first. The technique can also be used for less physical actions, such as a character looking off-screen to anticipate someone's arrival, or attention focusing on an object that a character is about to pick up.[10]

Anticipation: A baseball player making a pitch prepares for the action by moving his arm back.

Staging

This principle is akin to staging in theatre, as it is known in theatre and film.[11] Its purpose is to direct the audience's attention, and make it clear what is of greatest importance in a scene;[12] Johnston and Thomas defined it as "the presentation of any idea so that it is completely and unmistakably clear", whether that idea is an action, a personality, an expression, or a mood.[11] This can be done by various means, such as the placement of a character in the frame, the use of light and shadow, or the angle and position of the camera.[13] The essence of this principle is keeping focus on what is relevant, and avoiding unnecessary detail.[14][15]

Straight Ahead Action and Pose to Pose

These are two different approaches to the actual drawing process. Straight ahead action scenes are animated frame by frame from beginning to end, while "pose to pose" involves starting with drawing a few key frames, and then filling in the intervals later.[12] "Straight ahead action" creates a more fluid, dynamic illusion of movement, and is better for producing realistic action sequences. On the other hand, it is hard to maintain proportions, and to create exact, convincing poses along the way. "Pose to pose" works better for dramatic or emotional scenes, where composition and relation to the surroundings are of greater importance.[16] A combination of the two techniques is often used.[17]

Computer animation removes the problems of proportion related to "straight ahead action" drawing; however, "pose to pose" is still used for computer animation, because of the advantages it brings in composition.[18] The use of computers facilitates this method, and can fill in the missing sequences in between poses automatically. It is, however, still important to oversee this process and apply the other principles discussed.[17]

Follow Through and Overlapping Action

Follow through and overlapping action is a general heading for two closely related techniques which help to render movement more realistically, and help to give the impression that characters follow the laws of physics, including the principle of inertia. "Follow through" means that loosely tied parts of a body should continue moving after the character has stopped and the parts should keep moving beyond the point where the character stopped only to be subsequently "pulled back" towards the center of mass and/or exhibiting various degrees of oscillation damping. "Overlapping action" is the tendency for parts of the body to move at different rates (an arm will move on different timing of the head and so on). A third, related technique is "drag", where a character starts to move and parts of him take a few frames to catch up.[12] These parts can be inanimate objects like clothing or the antenna on a car, or parts of the body, such as arms or hair. On the human body, the torso is the core, with arms, legs, head and hair appendices that normally follow the torso's movement. Body parts with much tissue, such as large stomachs and breasts, or the loose skin on a dog, are more prone to independent movement than bonier body parts.[19] Again, exaggerated use of the technique can produce a comical effect, while more realistic animation must time the actions exactly, to produce a convincing result.[20]

The "moving hold" animates between similar key frames, even characters sitting still can display some sort of movement, such as the torso moving in and out with breathing.[21]

Slow In and Slow Out

The movement of the human body, and most other objects, needs time to accelerate and slow down. For this reason, animation looks more realistic if it has more drawings near the beginning and end of an action, emphasizing the extreme poses, and fewer in the middle.[12] This principle goes for characters moving between two extreme poses, such as sitting down and standing up, but also for inanimate, moving objects, like the bouncing ball in the above illustration.[22]

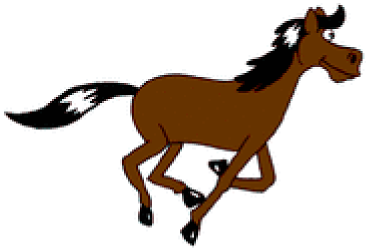
Arc

Most natural action tends to follow an arched trajectory, and animation should adhere to this principle by following implied "arcs" for greater realism. This technique can be applied to a moving limb by rotating a joint, or a thrown object moving along a parabolic trajectory. The exception is mechanical movement, which typically moves in straight lines.[23]

As an object's speed or momentum increases, arcs tend to flatten out in moving ahead and broaden in turns. In baseball, a fastball would tend to move in a straighter line than other pitches; while a figure skater moving at top speed would be unable to turn as sharply as a slower skater, and would need to cover more ground to complete the turn.

An object in motion that moves out of its natural arc for no apparent reason will appear erratic rather than fluid. For example, when animating a pointing finger, the animator should be certain that in all drawings in between the two extreme poses, the fingertip follows a logical arc from one extreme to the next. Traditional animators tend to draw the arc in lightly on the paper for reference, to be erased later.

Secondary Action



Secondary Action: as the horse runs, its mane and tail follow the movement of the body.

Adding secondary actions to the main action gives a scene more life, and can help to support the main action. A person walking can simultaneously swing their arms or keep them in their pockets, speak or whistle, or express emotions through facial expressions.[24] The important thing about secondary actions is that they emphasize, rather than take attention away from the main action. If the latter is the case, those actions are better left out.[25] For example, during a dramatic movement, facial expressions will often go unnoticed. In these cases it is better to include them at the beginning and the end of the movement, rather than during.[26]

Timing

"Timing (animation)" redirects here. For the animation technique, see Blocking (animation).

Timing refers to the number of drawings or frames for a given action, which translates to the speed of the action on film.[12] On a purely physical level, correct timing makes objects appear to obey the laws of physics; for instance, an object's weight determines how it reacts to an impetus, like a push.[27] Timing is critical for establishing a character's mood, emotion, and reaction.[12] It can also be a device to communicate aspects of a character's personality.[28]

Exaggeration

Exaggeration is an effect especially useful for animation, as animated motions that strive for a perfect imitation of reality can look static and dull.[12] The level of exaggeration depends on whether one seeks realism or a particular style, like a caricature or the style of a specific artist. The classical definition of exaggeration, employed by Disney, was to remain true to reality, just presenting it in a wilder, more extreme form.[29] Other forms of exaggeration can involve the supernatural or surreal, alterations in the physical features of a character; or elements in the storyline itself.[30] It is important to employ a certain level of restraint when using exaggeration. If a scene contains several elements, there should be a balance in how those elements are exaggerated in relation to each other, to avoid confusing or overawing the viewer.[31]

Solid drawing

The principle of solid drawing means taking into account forms in three-dimensional space, or giving them volume and weight.[12] The animator needs to be a skilled artist and has to understand the basics of three-dimensional shapes, anatomy, weight, balance, light and shadow, etc.[32] For the classical animator, this involved taking art classes and doing sketches from life.[33] One thing in particular that Johnston and Thomas warned against was creating "twins": characters whose left and right sides mirrored each other, and looked lifeless.[34] Modern-day computer animators draw less because of the facilities computers give them,[35] yet their work benefits greatly from a basic understanding of animation principles, and their additions to basic computer animation.[33]

Appeal

Appeal in a cartoon character corresponds to what would be called charisma in an actor.[36] A character who is appealing is not necessarily sympathetic – villains or monsters can also be appealing – the important thing is that the viewer feels the character is real and interesting.[36] There are several tricks for making a character connect better with the audience; for likable characters a symmetrical or particularly baby-like face tends to be effective.[37] A complicated or hard to read face will lack appeal, it may more accurately be described as 'captivation' in the composition of the pose, or the character design.

Sr.No	Title	Author	Publisher	Edition	Year of Edition
1	The illusion of life	Frank Thomas	-	-	-
2	Timing Animation	John Halos	-	-	-
3	The Animator's Survival Kit	Richard Williams	-	-	-
4	12 basic principles of animation	From Wikipedia	-	-	-
5			-		
6			-	-	-

Paper –III: Clay Animation 50 Hrs

Course Type: Theory / Practical	Theory
Required/Elective	Required
Prerequisite	Fundamentals of art & Type of perspective & principals of animation
Teaching Scheme (Lecture/Practical/Tutorial/Drawing)	02/02/00/00 Hours
Total contact Hours (Lecture/Practical/Tutorial/Drawing)	50/00/00/00 Hours
Evaluation Scheme: Theory Theory Paper /Term Work/Oral/Practical	--/--/--/--

Course Outcomes (COs):

Course Outcomes(COs): Upon completion of this course, students will be able to		Mapping with PO's
CO107.1	Clay animation involves stop motion filming techniques	5,6
CO107.2	Clay animators can provide artwork and special effects for television cartoons, films and video games.	2,7
CO107.3	2D and 3D animation, stop motion film and clay animation techniques	7
CO107.4	Visual development & Schematics	5,7
CO107.5	Film mechanics & Anatomy	7,9
CO107.6	Sculpting and character creation & Lighting techniques	2,7

Correlation matrix of Course outcomes with Programmed outcomes (CO-PO)
1=Low correlation, 2=Medium correlation, 3=High correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2
CO107.1	-	-	-	-	3	-	-	-		-	2
CO107.2	-	2	-	-	-	-	3	-	-	-	,2
CO107.3	-	-	-	-	-	-	3	-	-	-	2
CO107.4	-	-	-	-	2	-	2	-	-	-	1
CO107.5	-	2	-	-	-	-	2	-	3	-	2
CO107.6	-	2	-	-	-	-	2	-	-	-	2

Textbooks/Reference Books/ Other Books/E-material/Paper

Clay animation or **clay mation**, sometimes **plasticine animation**, is one of many forms of stop motion animation. Each animated piece, either character or background, is "deformable"—made of a malleable substance, usually plasticine clay.

Characters in the animated series *From Ilich to Kuzmich*

A clay animation scene from a Finnish TV commercial[1]

Traditional animation, from cel animation to stop motion, is produced by recording each frame, or still picture, on film or digital media and then playing the recorded frames back in rapid succession before the viewer. These and other moving images, from zoetrope to films to video games, create the illusion of motion by playing back at over ten to twelve frames per second. The techniques involved in creating computer-generated imagery are conversely generally removed from a frame-by-frame process.

Contents

Technique

Each object or character is sculpted from clay or other such similarly pliable material as plasticine, usually around a wire skeleton called an armature, and then arranged on the set, where it is photographed once before being slightly moved by hand to prepare it for the next shot, and so on until the animator has achieved the desired amount of film. Upon playback, the mind of the viewer perceives the series of slightly changing, rapidly succeeding images as motion.

A consistent shooting environment is needed to maintain the illusion of continuity: objects must be consistently placed and lit, and work must proceed in a calm environment.

Production

Producing a stop-motion animation using clay is extremely laborious. Normal film runs at 24 frames per second (frame/s). With the standard practice of "doubles" or "twos" (double-framing, exposing two frames for each shot) 12 changes are usually made for one second of film movement. [2] Shooting a 30-minute movie would therefore require making approximately 21,600 stops to change the figures for the frames; a full-length (90-minute) movie, 64,800—and possibly many more if some parts were shot with "singles" or "ones" (one frame exposed for each shot).

The object must not be altered by accident, slight smudges, dirt, hair, or dust. Feature-length productions have generally switched from clay to rubber silicone and resin cast components: Will Vinton has dubbed one foam-rubber process "Foamation". Nevertheless, clay remains a viable animation material where a particular aesthetic is desired.

Types

Clay animation can take several forms:

"Freeform" clay animation is an informal term referring to the process in which the shape of the clay changes radically as the animation progresses, such as in the work of Eli Noyes and Ivan Stang's animated films. Clay can also take the form of "character" clay animation, where the clay maintains a recognizable character throughout a shot,[3] as in Art Clokey's and Will Vinton's films.[4]

One variation of clay animation is strata-cut animation, in which a long bread-like loaf of clay, internally packed tight and loaded with varying imagery, is sliced into thin sheets, with the camera taking a frame of the end of the loaf for each cut, eventually revealing the movement of the internal images within. Pioneered in both clay and blocks of wax by German animator Oskar Fischinger during the 1920s and 1930s, the technique was revived and highly refined in the mid-1990s by David Daniels, an associate of Will Vinton, in his 16-minute short film "Buzz Box".

Another clay-animation technique, one that blurs the distinction between stop motion and traditional flat animation, is called clay painting (also a variation of the direct manipulation animation process), wherein clay is placed on a flat surface and moved like wet oil paints (as on a traditional artist's canvas) to produce any style of images, but with a clay look to them.

A sub variation clay animation can be informally called "clay melting".[5] Any kind of heat source can be applied on or near (or below) clay to cause it to melt while an animation camera on a time-lapse setting slowly films the process. For example, consider Vinton's early short clay-animated film *Closed Mondays* (co produced by animator Bob Gardiner) at the end of the computer sequence. A similar technique was used in the climax scene of *Raiders of the Lost Ark* to "melt" the faces of the antagonists.

The term "hot set" is used amongst animators during production. It refers to a set where an animator is filming. The clay characters are set in a perfect position where they can continue shooting where they left off. If an animator calls his set a "hot set," then no one is allowed to touch the set or else the shoot would be ruined. Certain scenes must be shot rather quickly. If a scene is left unfinished and the weather is perhaps humid, then the set and characters have an obvious difference. The clay puppets may be deformed from the humidity or the air pressure could have caused the set to shift slightly. These small differences can create an obvious flaw to the scene. To avoid these disasters, scenes normally have to be shot in one day or less.

History

Clay-animated films were produced in the United States as early as 1908, when Edison Manufacturing released a trick film entitled *The Sculptor's Welsh Rarebit Dream* (possibly referencing the comic strip *Dreams of a Rarebit Fiend*). In 1916, clay animation became something of a fad, as an East Coast artist named Helena Smith Dayton and a West Coast animator named Willie Hopkins produced clay-animated films on a wide range of subjects. Hopkins in particular was quite prolific, producing over fifty clay-animated segments for the weekly *Universal Screen Magazine*. By the 1920s, cartoon animation using either cels or the slash system was firmly established as the dominant mode of animation production. Increasingly, three-dimensional forms such as clay were driven into relative obscurity as the cel method became the preferred method for the studio cartoon.[6]

Nevertheless, in 1921, clay animation appeared in a film called "Modeling", an Out of the Inkwell film from the newly formed Fleischer Brothers studio. "Modeling" is one of the few known shorts using clay that was released during the 1920s. "Modeling" included animated clay in eight shots, a novel integration of the technique into an existing cartoon series and one of the rare uses of clay animation in a theatrical short from the 1920s.[6]

Pioneering the clay-painting technique was one-time Vinton animator Joan Gratz, first in her Oscar-nominated film *The Creation* (1980), and then in her Oscar-winning *Mona Lisa Descending a Staircase*, filmed in 1992. [7]

In 1972, at Marc Chinoy's Cineplast Films Studio in Munich, Germany, André Roche created a set of clay-animated German-language-instruction films (for non-German-speaking children) called *Kli-Kla-Klawitter* for the Second German TV-Channel; and another one for a traffic education series, *Herr Daniel paßt auf* ("Mr. Daniel Pays Attention").

A variation of clay animation was developed by another Vinton animator, Craig Bartlett, for his series of Arnold short films (also made in the late-1980s/early-1990s), in which he not only used clay painting but sometimes built up clay images that rose off the plane of the flat support platform toward the camera lens to give a more 3-D stop-motion look to his films.


Play media

Gumbasia (1955), early stop motion clay animation movie by Art Clokey

Some of the best-known clay-animated works include the Gumby series of television show segments (created by Art Clokey) [8] , The California Raisins advertising campaign by Will Vinton Productions studio and The WB's *The PJs*, produced by and featuring the voice of Eddie Murphy. Clay animation has also been used in Academy Award-winning short films such as *Closed Mondays* (Will Vinton and Bob Gardiner, 1974) [9], *The Sand Castle* (1977), *Creature*

Comforts (Aardman Animations, 1989), and all four Wallace and Gromit short films, created by Nick Park of Aardman Animations. Aardman also created *The Presentators*, a series of one-minute clay-animation/CGI short films aired on Nickelodeon UK. Some clay animations appear online, on such sites as Newgrounds. In addition, many of the Rankin/Bass holiday specials were clay-animated. [10]

Several computer games have also been produced using clay animation, including *The Neverhood*, *Clay Fighter*, *Platypus*, Clay Moon (iPhone app), and *Primal Rage*. Television commercials have also utilized the clay animation, such as the Chevron Cars ads, produced by Aardman Studios. Besides commercials, clay animation has also been popularized in recent years by children's shows such as *Pingu*, *Shaun the Sheep* and *Mio Mao* as well as adult-oriented shows on Cartoon Network's Adult Swim lineup, including *Robot Chicken* (which uses clay animation and action figures as stop-motion puppets in conjunction) and *Moral Orel*. Many independent young filmmakers have used clay animation features for internet viewing.

Flushed Away is a CGI replication of clay animation. [11] Probably the most spectacular use of model animation for a computer game was for the Virgin Interactive Entertainment Mythos game *Magic and Mayhem* (1998), for which stop-motion animator and special-effects expert Alan Friswell constructed over 25 monsters and mythological characters utilising both modelling clay and latex rubber, over wire and ball-and-socket skeletons. Rather than building the models in the cartoon-like style of Wallace and Gromit, Friswell constructed the figures after the designs of Willis O'Brien and Ray Harryhausen to make them more compatible with the game's often violent playing tactics.

Notable clay animators

- Virginia May [12]
- Will Vinton
- Eli Noyes
- Nick Park
- Art Clokey
- Joan C. Gratz

See also

- List of films featuring clay animation
- Stop-motion animation
- Cel animation

Footnotes

- "Case study: Chicken in Clay" (1997)
- • Animation Techniques: Stop-Motion-NFB Blog
- • Gumbo (2003)
- • Oddball Films: Stop-Motion Explosion III - Thur. Aug 15 - 8PM
- • *"Clay Animation – Clay Animation History". Wordpress. Retrieved 26 February 2013.*
- • *Frierson, Michael (1993). Clay comes out of the inkwell (in Animation Journal - Fall 1993).*
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- • [History of Clay Animation-Peeble Studios]
- • [Oddball Films: Will Vinton's Claymation Marvels - Thur. June 12 - 8PM]
- • [A History of Clay Animation-ABC News]
- • *"First look at Aardman's rat movie". BBC News Online. BBC. 16 February 2006.*

TextBooks/ReferenceBooks/ OtherBooks/E-material/Paper

Sr.No	Title	Author	Publisher	Edition	Year of Edition
1	Serels of Clay Animation	Mare Spess	-	-	-
2	Stop Motion	Susannah Shaw	-	-	-
3	Clay magic	Steven Offinoski	-	-	-
4	Animation	Mary Murphy	-	-	-
5	Chicken run	Brea Sibley	-	-	-
6	Stop Motion	Meliyn Ternan	-	-	-

PAPER IV :- 3-D Modeling & Texturing 50hrs

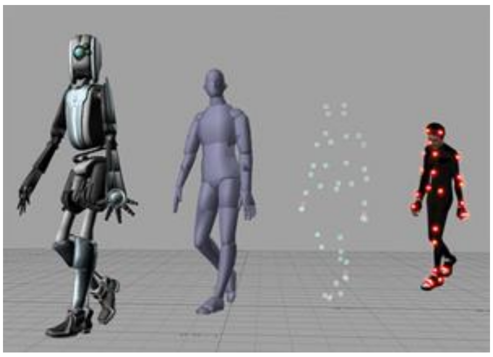
Course Type: Theory / Practical	Theory
Required/Elective	Required
Prerequisite	Classical animation & clay anaimation
Teaching Scheme (Lecture/Practical/Tutorial/Drawing)	04/04/00/00 Hours
Total contact Hours (Lecture/Practical/Tutorial/Drawing)	50/00/00/00 Hours
Evaluation Scheme: Theory Theory Paper /Term Work/Oral/Practical	--/--/--/--

Course Outcomes (COs):

Course Outcomes(COs): Uponcompletion of this course, students will be able to		Mapping with PO's
CO107.1	Introduction to 3-D Modeling	4,9
CO107.2	Modeling, Texture Mapping and Lighting	4,7
CO107.3	Animation Environment Layout	5,7
CO107.4	Advanced 3-D Modeling Animation	5
CO107.5	Demo-Reel & 3-D Character Rigging	2,9
CO107.6	3D Animator	1,2,7

Correlation matrix of Course outcomes with Programmed outcomes (CO-PO)
1=Low correlation, 2=Medium correlation, 3=High correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2
CO107.1	-	-	-	3	-	-	-	-	2	-	2
CO107.2	-	-	-	3	1	-	2	-	-	-	2
CO107.3	-	-	-	-	3	-	2	-	-	-	2
CO107.4	-	-	-	-	3	-	-	-	-	-	2
CO107.5	-	2	-	-	-	-	-	-		-	2
CO107.6	1	2	-	-	-	-	-	-	3	-	1,2



An example of computer animation which is produced in the "motion capture" technique

Computer animation is the process used for generating animated images. The more general term computer-generated imagery (CGI) encompasses both static scenes and dynamic images, while computer animation *only* refers to the moving images. Modern computer animation usually uses 3D computer graphics, although 2D computer graphics are still used for stylistic, low bandwidth, and faster real-time renderings. Sometimes, the target of the animation is the computer itself, but sometimes film as well.

Computer animation is essentially a digital successor to the stop motion techniques using 3D models, and traditional animation techniques using frame-by-frame animation of 2D illustrations. Computer-generated animations are more controllable than other more physically based processes, constructing miniatures for effects shots or hiring extras for crowd scenes, and because it allows the creation of images that would not be feasible using any other technology. It can also allow a single graphic artist to produce such content without the use of actors, expensive set pieces, or props. To create the illusion of movement, an image is displayed on the computer monitor and repeatedly replaced by a new image that is similar to it, but advanced slightly in time (usually at a rate of 24, 25 or 30 frames/second). This technique is identical to how the illusion of movement is achieved with television and motion pictures.

For 3D animations, objects (models) are built on the computer monitor (modeled) and 3D figures are rigged with a virtual skeleton. For 2D figure animations, separate objects (illustrations) and separate transparent layers are used with or without that virtual skeleton. Then the limbs, eyes, mouth, clothes, etc. of the figure are moved by the animator on key frames. The differences in appearance between key frames are automatically calculated by the computer in a process known as tweening or morphing. Finally, the animation is rendered.[1]

For 3D animations, all frames must be rendered after the modeling is complete. For 2D vector animations, the rendering process is the key frame illustration process, while tweened frames are rendered as needed. For pre-recorded presentations, the rendered frames are transferred to a different format or medium, like digital video. The frames may also be rendered in real time as they are presented to the end-user audience. Low bandwidth animations transmitted via the internet (e.g. Adobe Flash, X3D) often use software on the end-users computer to render in real time as an alternative to streaming or pre-loaded high bandwidth animations.

Contents

Explanation

To trick the eye and the brain into thinking they are seeing a smoothly moving object, the pictures should be drawn at around 12 frames per second or faster.[2] (A frame is one complete image.) With rates above 75-120 frames per second, no improvement in realism or smoothness is perceivable due to the way the eye and the brain both process images. At rates below 12 frames per second, most people can detect jerkiness associated with the drawing of new images that detracts from the illusion of realistic movement.[3] Conventional hand-drawn cartoon animation often uses 15 frames per second in order to save on the number of drawings needed, but this is usually accepted because of the stylized nature of cartoons. To produce more realistic imagery, computer animation demands higher frame rates.

Films seen in theaters in the United States run at 24 frames per second, which is sufficient to create the illusion of continuous movement. For high resolution, adapters are used.

History

Main article: History of computer animation

See also: Timeline of computer animation in film and television

Early digital computer animation was developed at Bell Telephone Laboratories in the 1960s by Edward E. Zajac, Frank W. Sinden, Kenneth C. Knowlton, and A. Michael Noll.[4] Other digital animation was also practiced at the Lawrence Livermore National Laboratory.[5]

In 1967, a computer animation named "Hummingbird" was created by Charles Csuri and James Shaffer.[6]

In 1968, a computer animation called "Kitty" was created with BESM-4 by Nikolai Konstantinov, depicting a cat moving around.[7]

In 1971, a computer animation called "Metadata" was created, showing various shapes.[8]

An early step in the history of computer animation was the sequel to the 1973 film *Westworld*, a science-fiction film about a society in which robots live and work among humans.[9] The sequel, *Futureworld* (1976), used the 3D wire-frame imagery, which featured a computer-animated hand and face both created by University of Utah graduates Edwin Catmull and Fred Parke.[10] This imagery originally appeared in their student film *A Computer Animated Hand*, which they completed in 1972.[11][12]

Developments in CGI technologies are reported each year at SIGGRAPH,[13] an annual conference on computer graphics and interactive techniques that is attended by thousands of computer professionals each year.[14] Developers of computer games and 3D video cards strive to achieve the same visual quality on personal computers in real-time as is possible for CGI films and animation. With the rapid advancement of real-time rendering quality, artists began to use game engines to render non-interactive movies, which led to the art form Machinima.

The very first full length computer animated television series was *ReBoot*,[15] which debuted in September 1994; the series followed the adventures of characters who lived inside a computer.[16] The first feature-length computer animated film was *Toy Story* (1995), which was made by Pixar.[17][18][19] It followed an adventure centered around toys and their owners. This groundbreaking film was also the first of many fully computer-animated movies.[18]

Animation methods

In this .gif of a 2D Flash animation, each 'stick' of the figure is keyframed over time to create motion.

In most 3D computer animation systems, an animator creates a simplified representation of a character's anatomy, which is analogous to a skeleton or stick figure.[20] The position of each segment of the skeletal model is defined by animation variables, or Avars for short. In human and animal characters, many parts of the skeletal model correspond to the actual bones, but skeletal animation is also used to animate other things, with facial features (though other methods for facial animation exist).[21] The character "Woody" in *Toy Story*, for example, uses 700 Avars (100 in the face alone). The computer doesn't usually render the skeletal model directly (it is invisible), but it does use the skeletal model to compute the exact position and orientation of that certain character, which is eventually rendered into an image. Thus by changing the values of Avars over time, the animator creates motion by making the character move from frame to frame.

There are several methods for generating the Avar values to obtain realistic motion. Traditionally, animators manipulate the Avars directly.[22] Rather than set Avars for every frame, they usually set Avars at strategic points (frames) in time and let the computer interpolate or tween between them in a process called *keyframing*. Keyframing puts control in the hands of the animator and has roots in hand-drawn traditional animation.[23]

In contrast, a newer method called *motion capture* makes use of live action footage.[24] When computer animation is driven by motion capture, a real performer acts out the scene as if they were the character to be animated.[25] His/her motion is recorded to a computer using video cameras and markers and that performance is then applied to the animated character.[26]

Each method has its advantages and as of 2007, games and films are using either or both of these methods in productions. Keyframe animation can produce motions that would be difficult or impossible to act out, while motion capture can reproduce the subtleties of a particular actor.[27] For example, in the 2006 film *Pirates of the Caribbean: Dead Man's Chest*, Bill Nighy provided the performance for the character Davy Jones. Even though Nighy doesn't appear in the movie himself, the movie benefited from his performance by recording the nuances of his body language, posture, facial expressions, etc. Thus motion capture is appropriate in situations where believable, realistic behavior and action is required, but the types of characters required exceed what can be done throughout the conventional costuming.

Modeling

3D computer animation combines 3D models of objects and programmed or hand "keyframed" movement. These models are constructed out of geometrical vertices, faces, and edges in a 3D coordinate system. Objects are sculpted much like real clay or plaster, working from general forms to specific details with various sculpting tools. Unless a 3D model is intended to be a solid color, it must be painted with "textures" for realism. A bone/joint animation system is set up to deform the CGI model (e.g., to make a humanoid model walk). In a process known as *rigging*, the virtual marionette is given various controllers and handles for controlling movement.[28]

Animation data can be created using motion capture, or keyframing by a human animator, or a combination of the two.[29]

3D models rigged for animation may contain thousands of control points — for example, "Woody" from *Toy Story* uses 700 specialized animation controllers. Rhythm and Hues Studios labored for two years to create Aslan in the movie *The Chronicles of Narnia: The Lion, the Witch and the Wardrobe*, which had about 1,851 controllers (742 in the face alone). In the 2004 film *The Day After Tomorrow*, designers had to design forces of extreme weather with the help of video references and accurate meteorological facts. For the 2005 remake of *King Kong*, actor Andy Serkis was used to help designers pinpoint the gorilla's prime location in the shots and used his expressions to model "human" characteristics onto the creature. Serkis had earlier provided the voice and performance for Gollum in J. R. R. Tolkien's *The Lord of the Rings* trilogy.

Equipment

A ray-traced 3-D model of a jack inside a cube, and the jack alone below.

Computer animation can be created with a computer and an animation software. Some impressive animation can be achieved even with basic programs; however, the rendering can take a lot of time on an ordinary home computer.[30] Professional animators of movies, television and video games could make photorealistic animation with high detail. This level of quality for movie animation would take hundreds of years to create on a home computer. Instead, many powerful workstation computers are used.[31] Graphics workstation computers use two to four processors, and they are a lot more powerful than an actual home computer and are specialized for rendering. A large number of workstations (known as a "*render farm*") are networked together to effectively act as a giant computer.[32] The result is a computer-animated movie that can be completed in about one to five years (however, this process is not composed solely of rendering). A workstation typically costs $2,000-16,000 with the more expensive stations being able to render much faster due to the more technologically-advanced hardware that they contain. Professionals also use digital movie cameras, motion/performance capture, bluescreens, film editing software, props, and other tools used for movie animation.

Facial animation

Main article: Computer facial animation

The realistic modeling of human facial features is both one of the most challenging and sought after elements in computer-generated imagery. Computer facial animation is a highly complex field where models typically include a very large number of animation variables.[33] Historically speaking, the first SIGGRAPH tutorials on *State of the art in Facial Animation* in 1989 and 1990 proved to be a turning point in the field by bringing together and consolidating multiple research elements and sparked interest among a number of researchers.[34]

The Facial Action Coding System (with 46 "action units", "lip bite" or "squint"), which had been developed in 1976, became a popular basis for many systems.[35] As early as 2001, MPEG-4 included 68 Face Animation Parameters (FAPs) for lips, jaws, etc., and the field has made significant progress since then and the use of facial microexpression has increased.[35][36]

In some cases, an affective space, the PAD emotional state model, can be used to assign specific emotions to the faces of avatars.[37] In this approach, the PAD model is used as a high level emotional space and the lower level space is the MPEG-4 Facial Animation Parameters (FAP). A mid-level Partial Expression Parameters (PEP) space is then used to in a two-level structure – the PAD-PEP mapping and the PEP-FAP translation model.[38]

Realism

Realism in computer animation can mean making each frame look photorealistic, in the sense that the scene is rendered to resemble a photograph or make the characters' animation believable and lifelike.[39] Computer animation can also be realistic with or without the photorealistic rendering.[40]

One of the greatest challenges in computer animation has been creating human characters that look and move with the highest degree of realism. Part of the difficulty in making pleasing, realistic human characters is the uncanny valley, the concept where the human audience (up to a point) tends to have an increasingly negative, emotional response as a human replica looks and acts more and more human. Films that have attempted photorealistic human characters, such as *The Polar Express*,[41][42][43] *Beowulf*,[44] and *A Christmas Carol*[45][46] have been criticized as "creepy" and "disconcerting".

The goal of computer animation is not always to emulate live action as closely as possible, so many animated films instead feature characters who are anthropomorphic animals, fantasy creatures and characters, superheroes, or otherwise have non-realistic, cartoon-like proportions.[47] Computer animation can also be tailored to mimic or substitute for other kinds of animation, like traditional stop-motion animation (as shown in *Flushed Away* or *The Lego Movie*). Some of the long-standing basic principles of animation, like squash & stretch, call for movement that is not strictly realistic, and such principles still see widespread application in computer animation.[48]

Films

CGI film made using Machinima

CGI short films have been produced as independent animation since 1976.[49] An early example of an animated feature film to incorporate CGI animation was the 1983 Japanese anime film *Golgo 13: The Professional*.[50] The popularity of computer animation (especially in the field of special effects) skyrocketed during the modern era of U.S. animation.[51] The first completely computer-animated movie was *Toy Story* (1995), but *VeggieTales* is the first American fully 3D computer animated series sold directly (made in 1993); its success inspired other animation series, such as *ReBoot* in 1994.

Animation studios

Some notable producers of computer-animated feature films include:

- Animal Logic – Films include *Happy Feet* (2006), *Legend of the Guardians: The Owls of Ga'Hoole* (2010), *Walking with Dinosaurs* (2013) and *The Lego Movie* (2014)
- Blue Sky Studios – Films include *Ice Age* (2002), *Robots* (2005), *Horton Hears a Who!* (2008), *Rio* (2011), *The Peanuts Movie* (2015)
- DreamWorks Animation – Films include *Shrek* (2001), *Madagascar* (2005), *Over the Hedge* (2006), *Bee Movie* (2007), *Kung Fu Panda* (2008), *Monsters vs. Aliens* (2009), *How to Train Your Dragon* (2010), *Rise of the Guardians* (2012), *The Croods* (2013), *How to Train Your Dragon 2* (2014), *Kung Fu Panda 3* (2016)
- Ilion Animation Studios — Films include *Planet 51* (2009), *Mortadelo and Filemon: Mission Implausible* (2014)*Wonder Park* (2019) And *Luck (2021).*
- Illumination Entertainment — Films include *Despicable Me* (2010), *The Lorax* (2012), *Minions* (2015), *The Secret Life of Pets* (2016), *Sing* (2016) and *The Grinch* (2018)
- Industrial Light & Magic – Films include *Rango* (2011) and *Strange Magic* (2015)
- Pacific Data Images – Films include *Antz* (1998), *Shrek* (2001), *Madagascar* (2005), *Megamind* (2010), *Mr. Peabody and Sherman* (2014)
- Pixar Animation Studios – Films include *Toy Story* (1995), *A Bug's Life* (1998), *Monsters, Inc.* (2001), *Finding Nemo* (2003), *Cars* (2006)
- Reel FX Animation Studios – Films include *Free Birds* (2013) and *The Book of Life* (2014)
- Sony Pictures Animation – Films include *Open Season* (2006), *Surf's Up* (2007), *Cloudy with a Chance of Meatballs* (2009), *The Smurfs* (2011), *Hotel Transylvania* (2012), *Cloudy with a Chance of Meatballs 2* (2013), *Hotel Transylvania 2* (2015) and *The Emoji Movie* (2017)
- Sony Pictures Imageworks – Films include *The Angry Birds Movie* (2016)
- Walt Disney Animation Studios – Films include *Tangled* (2010), *Wreck-It Ralph* (2012), *Frozen* (2013), *Big Hero 6* (2014), *Zootopia* (2016), *Moana* (2016)
- Warner Animation Group – Films include *The Lego Movie* (2014), *Storks* (2016), *The Lego Batman Movie* (2017) and *Smallfoot* (2018).
- Triggerfish Animation Studios – Films include *Zambezia (film)* (2013), *Khumba* (2014)

Web animations

The popularity of websites that allow members to upload their own movies for others to view has created a growing community of amateur computer animators.[52] With utilities and programs often included free with modern operating systems, many users can make their own animated movies and shorts. Several free and open-source animation software applications exist as well. The ease at which these animations can be distributed has attracted professional animation talent also. Companies such as PowToon and GoAnimate attempt to bridged the gap by giving amateurs access to professional animations as clip art.

The oldest (most backward compatible) web-based animations are in the animated GIF format, which can be uploaded and seen on the web easily.[53] However, the raster graphics format of GIF animations slows the download and frame rate, especially with larger screen sizes. The growing demand for higher quality web-based animations was met by a vector graphics alternative that relied on the use of a plugin. For decades, Flash animations were the most popular format, until the web development community abandoned support for the Flash player plugin. Web browsers on mobile devices and mobile operating systems never fully supported the Flash plugin.

By this time, internet bandwidth and download speeds increased, making raster graphic animations more convenient. Some of the more complex vector graphic animations had a slower frame rate due to complex rendering than some of the raster graphic alternatives. Many of the GIF and Flash animations were already converted to digital video formats, which were compatible with mobile devices and reduced file sizes via video compression technology. However, compatibility was still problematic as some of the popular video formats such as Apple's QuickTime and Microsoft Silverlight required plugins. YouTube, the most popular video viewing website, was also relying on the Flash plugin to deliver digital video in the Flash Video format.

The latest alternatives are HTML5 compatible animations. Technologies such as JavaScript and CSS animations made sequencing the movement of images in HTML5 web pages more convenient. SVG animations offered a vector graphic alternative to the original Flash graphic format, SmartSketch. YouTube offers an HTML5 alternative for digital video. APNG (Animated PNG) offered a raster graphic alternative to animated GIF files that enables multi-level transparency not available in GIFs

See also: Comparison of HTML5 and Flash

Detailed examples and pseudocode

In 2D computer animation, moving objects are often referred to as "sprites." A sprite is an image that has a location associated with it. The location of the sprite is changed slightly, between each displayed frame, to make the sprite appear to move.[54] The following pseudocode makes a sprite move from left to right:

Computer animation uses different techniques to produce animations. Most frequently, sophisticated mathematics is used to manipulate complex three-dimensional polygons, apply "textures", lighting and other effects to the polygons and finally rendering the complete image. A sophisticated graphical user interface may be used to create the animation and arrange its choreography. Another technique called constructive solid geometry defines objects by conducting boolean operations on regular shapes, and has the advantage that animations may be accurately produced at any resolution.

Computer-assisted vs. computer-generated

To animate means, figuratively, to "give life to". There are two basic methods that animators commonly use to accomplish this.

Computer-assisted animation is usually classed as two-dimensional (2D) animation. Drawings are either hand drawn (pencil to paper) or interactively drawn (on the computer) using different assisting appliances and are positioned into specific software packages. Within the software package, the creator places drawings into different key frames which fundamentally create an outline of the most important movements.[55] The computer then fills in the "in-between frames", a process commonly known as Tweening.[56] Computer-assisted animation employs new technologies to produce content faster than is possible with traditional animation, while still retaining the stylistic elements of traditionally drawn characters or objects.[57]

Computer-generated animation is known as three-dimensional (3D) animation. Creators design an object or character with an X, a Y and a Z axis. No pencil-to-paper drawings create the way computer generated animation works. The object or character created will then be taken into a software, key framing and tweening are also carried out in computer generated animation but are also a lot of techniques used that do not relate to traditional animation. Animators can break physical laws by using mathematical algorithms to cheat mass, force and gravity rulings. Fundamentally, time scale and quality could be said to be a preferred way to produce animation as they are two major things that are enhanced by using computer generated animation. Another positive aspect of CGA is the fact one can create a flock of creatures to act independently when created as a group. An animal's fur can be programmed to wave in the wind and lie flat when it rains instead of programming each strand of hair separately.[57]

A few examples of computer-generated animation movies are *Toy Story*, *Frozen*, and *Shrek*.

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Sr.No	Title	Author	Publisher	Edition	Year of Edition
1	Serials of Clay Animation	Mare Specs	-	-	-
2	Stop Motion	Susannah Shaw	-	-	-
3	Clay magic	Steven Offinoski	-	-	-
4	Animation	Mary Murphy	-	-	-
5	Chicken run	Brea Sibley	-	-	-
6	Stop Motion	Meliyn Ternan	-	-	-

A) Practical **50 Hrs.**

1 . Story Board 2. Light Box 3. Principles of Animation

4. stop motion 5. Advance Photoshop / Adobe Flash (2D)

B) Practical **100 Hrs.**

1. Maya 3D Modeling 2. Industrial Modeling 3. Character Modeling

4. Medical Modeling 5. Vehicle Modeling

C) Project Work **50Hrs.**

1. Photoshop/ Flash Work

2. Modeling Demo Reel

Semester -II

Paper Number	Title of Paper (For Semester IV)	Total Marks
V	Fundamentals Of Financial Accountings - 2	40 + 10 = 50
VI	Cinematography & Camera Angle	40 + 10 = 50
VII	Lightings & Rendering	40 + 10 = 50
VIII	3D Rigging	40 + 10 = 50
	TOTAL	**200**

The practical examination will be of 200 marks.

Sr. No.	Practical examination	Marks	Internal Assessment	Marks
1	Practical	180	Projects/ Industry Visit	50
2	Portfolio	20		
	Total	200		50

The total weightage of second term is of 450 marks, the details of which are-

Sr. No.	Title	Marks
1	Theory Examination 50 X 4	200
2	Practical Examination.	200
3	Internal Assessment	50
	TOTAL	**450**

B. Nature of question paper:
For the **papers VI to VIII** there will be in all **SEVEN** questions in each paper of which any **FIVE** should be solved. All questions will carry equal marks i.e. each question will be of 10 marks.
General nature of the question paper will be:

Question Number	Type	
Q.1	Short answer	Any two out of three
Q.2,3,4,5,6	Long answer	No internal options.
Q.7	Short notes	Any two out of three

SYLLABUS:
N. B.
(i) Figures shown in bracket indicate the total lectures required for the respective units.
(ii) The question paper should cover the entire syllabus. Marks allotted to questions should be in proportion to the lectures allotted to respective to units.
(iii) All units should be dealt with S.I. units.
(iv) Project / Industrial visit per semester is compulsory.
(v) Use of recent editions of reference books is essential.

(vi) Use of Output Devise al

SEMESTER II

Paper I-FUNDAMENTALS OF FIANACIAL ACCOUNTING- II

Work Load - 6		Total Marks – 50
Theory – 4 Lectures / Week Practical- 2 Lectures / Week		Theory- 40 Practical- 10

Objectives: To impact basic accounting knowledge as applicable to business.

Course contents:

Unit I **Computerized Accounting System**
Introduction – Concept – Components –Features - Importance and Utilization of Computerized Accounting System.

Unit II **Computer Application through Accounting Package Tally**
Creation of Company, Group, Ledger Accounts, Feeding of Accounting Data Receipts, Payments, Purchase, Sale, Contra, Journal, Credit Note and Debit NoteInventory Information – Groups, Items and Valuation.
Generation of various Accounting Reports.

Unit III **Accounts of Professionals**
Preparation of Receipts and Payment Account – Income and Expenditure Account and Balance Sheets of Non Profit Organization.

Unit IV **Single Entry System**
Conversion of Single Entry System into Double Entry System.

Practical:

1. Understanding computerized accounting practices applied in different retail malls in and around Kolhapur city
2. Practical problems based on computerized accounting using Tally
3. Practical problems on preparation of Receipts and Payment Account
4. Preparation of Income and Expenditure account and Balance Sheet of Non-profit making organizations
5. Solving the problems on conversion of Single Entry system into Double entry system.
6. Oral / Seminar

References:

1. Advanced Accountancy, M. C. Shukla and T. S. Garewal.
2. Advanced Accountancy, S.C. Jain and K. L. Narang.
3. Advanced Accountancy, S.N. Maheshwari.
4. Theory and practice of Computer Accounting, Rajan Chougule and Dhaval Chougule.

Web sites:

1) www.nos.org
2) www.wiki.answers.com
3) Chow.com

Scheme of External Practical Examination **10 marks**

1) Submission of Record book 5 marks
2) Viva – Voce 5 marks

Paper –VI : Cinematography & Camera Angle 100hrs

Course Teacher:	Mr. Ananda Maruti Sawant
Course Type: Theory / Practical	Theory
Required/Elective	Required
Prerequisite	2D animation & 3D animation
Teaching Scheme (Lecture/Practical/Tutorial/Drawing)	02/02/00/00 Hours
Total contact Hours (Lecture/Practical/Tutorial/Drawing)	50/00/00/00 Hours
EvaluationScheme: Theory Theory Paper /Term Work/Oral/Practical	--/--/--/--

Course Outcomes (COs):

CourseOutcomes(COs): Uponcompletionofthiscourse,studentswillbe able to		Mapping with PO's
CO107.1	technical control over the basic elements of photography, including exposure, lighting and composition.	4,9
CO107.2	Develop an understanding of collaboration between the cinematographer and director. Prepare basic pre-production materials to support the production of a short film.	4,7
CO107.3	Demonstrate basic skills in the roles of camera assistant, gaffer and key grip.	5,7
CO107.4	Explore the progression of technology and broad artistic trends throughout the history of filmmaking.	5
CO107.5	Explore the progression of technology and broad artistic trends throughout the history of filmmaking.	2,9
CO107.6	Analyze a screenplay from the perspective of a cinematographer. Utilize color correction tools to achieve the cinematographer's visual goals.	1,2,7

Correlation matrix of Course outcomes with Programmed outcomes (CO-PO)
1=Low correlation, 2=Medium correlation, 3=High correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2
CO107.1	-	-	-	3	-	-	-	-	2	-	2
CO107.2	-	-	-	3	1	-	2	-	-	-	2
CO107.3	-	-	-	-	3	-	2	-	-	-	2
CO107.4	-	-	-	-	3	-	-	-	-	-	2
CO107.5	-	2	-	-	-	-	-	-		-	2
CO107.6	1	2	-	-	-	-	-	-	3	-	1,2

Digital video camera

Part of a series on

Filmmaking

Development[show]

Pre-production[show]

Production[show]

Post-production[show]

Distribution[show]

Related topics[show]

Glossary[show]

See also[show]

Cinematography (from ancient greek κίνημα, *kìnema* "movement" and γράφειν, *gràphein* "to write") is the science or art of motion-picture photography by recording light or other electromagnetic radiation, either electronically by means of an image sensor, or chemically by means of a light-sensitive material such as film stock.[1]

Cinematographers use a lens to focus reflected light from objects into a real image that is transferred to some image sensor or light-sensitive material inside a movie camera. These exposures are created sequentially and preserved for later processing and viewing as a motion picture. Capturing images with an electronic image sensor produces an electrical charge for each pixel in the image, which is electronically processed and stored in a video file for subsequent processing or display. Images captured with photographic emulsion result in a series of invisible latent images on the film stock, which are chemically "developed" into a visible image. The images on the film stock are projected for viewing the motion picture.

Cinematography finds uses in many fields of science and business as well as for entertainment purposes and mass communication.

The word "cinematography" is based on the Greek words κίνημα (*kinema*), meaning "movement, motion" and γράφειν (*graphein*) meaning "to record", together meaning "recording motion". The word used to refer to the art, process, or job of filming movies, but later its meaning became restricted to "motion picture photography".

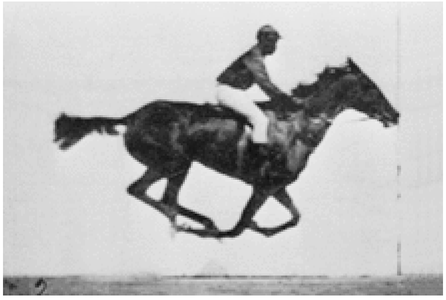
Contents

History

Main article: History of film technology

See also: History of the camera

Precursors



Muybridge sequence of a horse galloping

In the 1830s, moving images were produced on revolving drums and disks, with independent invention by Simon von Stampfer (stroboscope) in Austria, Joseph Plateau (phenakistoscope) in Belgium, and William Horner (zoetrope) in Britain.

In 1845, Francis Ronalds invented the first successful camera able to make continuous recordings of the varying indications of meteorological and geomagnetic instruments over time. The cameras were supplied to numerous observatories around the world and some remained in use until well into the 20th century.[2][3][4]

William Lincoln patented a device, in 1867, that showed animated pictures called the "wheel of life" or "zoopraxiscope". In it, moving drawings or photographs were watched through a slit.

On 19 June 1873, Eadweard Muybridge successfully photographed a horse named "Sallie Gardner" in fast motion using a series of 24 stereoscopic cameras. The cameras were arranged along a track parallel to the horse's, and each camera shutter was controlled by a trip wire triggered by the horse's hooves. They were 21 inches apart to cover the 20 feet taken by the horse stride, taking pictures at one thousandth of a second.[5] At the end of the decade, Muybridge had adapted sequences of his photographs to a zoopraxiscope for short, primitive projected "movies," which were sensations on his lecture tours by 1879 or 1880.

Nine years later, in 1882, French scientist Étienne-Jules Marey invented a chronophotographic gun, which was capable of taking 12 consecutive frames a second, recording all the frames of the same picture.

The late nineteenth to the early twentieth century brought rise to the use of film not only for entertainment purposes but for scientific exploration as well. French biologist and filmmaker Jean Painleve lobbied heavily for the use of film in the scientific field, as the new medium was more efficient in capturing and documenting the behavior, movement, and environment of microorganisms, cells, and bacteria, than the naked eye.[6] The introduction of film into scientific fields allowed for not only the viewing "new images and objects, such as cells and natural objects, but also the viewing of them in real time",[6] whereas prior to the invention of moving pictures, scientists and doctors alike had to rely on hand drawn sketches of human anatomy and its microorganisms. This posed a great inconvenience in the science and medical worlds. The development of film and increased usage of cameras allowed doctors and scientists to grasp a better understanding and knowledge of their projects.

Film cinematography

Main article: Film stock

Play media

Roundhay Garden Scene (1888), the world's earliest surviving motion-picture film.

The experimental film *Roundhay Garden Scene*, filmed by Louis Le Prince on 14 October 1888, in Roundhay, Leeds, England, is the earliest surviving motion picture. This movie was shot on paper film.

W. K. L. Dickson, working under the direction of Thomas Alva Edison, was the first to design a successful apparatus, the Kinetograph, patented in 1891. This camera took a series of instantaneous photographs on standard Eastman Kodak photographic emulsion coated onto a transparent celluloid strip 35 mm wide. The results of this work were first shown in public in 1893, using the viewing apparatus also designed by Dickson, the Kinetoscope. Contained within a large box, only one person at a time looking into it through a peephole could view the movie.

In the following year, Charles Francis Jenkins and his projector, the Phantoscope, made a successful audience viewing while Louis and Auguste Lumière perfected the Cinématographe, an apparatus that took, printed, and projected film, in Paris in December 1895. The Lumière brothers were the first to present projected, moving, photographic, pictures to a paying audience of more than one person.

In 1896, movie theaters were open in France (Paris, Lyon, Bordeaux, Nice, Marseille); Italy (Rome, Milan, Naples, Genoa, Venice, Bologna, Forlì); Brussels; and London.

In 1896, Edison showed his improved Vitascope projector, the first commercially successful projector in the U.S.

Cooper Hewitt invented mercury lamps which made it practical to shoot films indoors without sunlight in 1905.

The first animated cartoon was produced in 1906.

Credits began to appear at the beginning of motion pictures in 1911.

The Bell and Howell 2709 movie camera invented in 1915 allowed directors to make close-ups without physically moving the camera.

By the late 1920s, most of the movies produced were sound films.

Wide screen formats were first experimented with in the 1950s.

By the 1970s, most movies were color films. IMAX and other 70mm formats gained popularity. Wide distribution of films became commonplace, setting the ground for "blockbusters."

Film cinematography dominated the motion picture industry from its inception until the 2010s when digital cinematography became dominant. Film cinematography is still used by some directors, especially in specific applications or out of fondness of the format.

Black and white

From its birth in the 1880s, movies were predominantly monochrome. Contrary to popular belief, monochrome doesn't always mean black and white; it means a movie shot in a single tone or color. Since the cost of tinted film bases was substantially higher, most movies were produced in black and white monochrome. Even with the advent of early color experiments, the greater expense of color meant films were mostly made in black and white until the 1950s, when cheaper color processes were introduced, and in some years the percentage of films shot on color film surpassed 51%. By the 1960s, color became by far the dominant film stock. In the coming decades, the usage of color film greatly increased while monochrome films became scarce.

Color

Main article: Color motion picture film


Play media

Annabelle Serpentine Dance, hand-tinted version (1895)

After the advent of motion pictures, a tremendous amount of energy was invested in the production of photography in natural color.[7] The invention of the talking picture further increased the demand for the use of color photography. However, in comparison to other technological advances of the time, the arrival of color photography was a relatively slow process.[8]

Early movies were not actually color movies since they were shot monochrome and hand-colored or machine-colored afterwards. (Such movies are referred to as *colored* and not *color*.) The earliest such example is the hand-tinted Annabelle Serpentine Dance in 1895 by Edison Manufacturing Company. Machine-based tinting later became popular. Tinting continued until the advent of natural color cinematography in the 1910s. Many black and white movies have been colorized recently using digital tinting. This includes footage shot from both world wars, sporting events and political propaganda.

In 1902, Edward Raymond Turner produced the first films with a natural color process rather than using colorization techniques.[9] In 1908, kinemacolor was introduced. In the same year, the short film *A Visit to the Seaside* became the first natural color movie to be publicly presented.

In 1917, the earliest version of Technicolor was introduced. Kodachrome was introduced in 1935. Eastmancolor was introduced in 1950 and became the color standard for the rest of the century.

In the 2010s, color films were largely superseded by color digital cinematography.

Digital cinematography

Main article: Digital cinematography

See also: Digital movie camera and Digital cinema

Arri Alexa, a digital movie camera.

In digital cinematography, the movie is shot on digital medium such as flash storage, as well as distributed through a digital medium such as a hard drive.

Beginning in the late 1980s, Sony began marketing the concept of "electronic cinematography," utilizing its analog Sony HDVS professional video cameras. The effort met with very little success. However, this led to one of the earliest digitally shot feature movies, *Julia and Julia*, being produced in 1987.[10] In 1998, with the introduction of HDCAM recorders and 1920 × 1080 pixel digital professional video cameras based on CCD technology, the idea, now re-branded as "digital cinematography," began to gain traction in the market.[*citation needed*]

Shot and released in 1998, *The Last Broadcast* is believed by some to be the first feature-length video shot and edited entirely on consumer-level digital equipment.[11] In May 1999, George Lucas challenged the supremacy of the movie-making medium of film for the first time by including footage filmed with high-definition digital cameras in *Star Wars: Episode I – The Phantom Menace*. In late 2013, Paramount became the first major studio to distribute movies to theaters in digital format, eliminating 35mm film entirely. Since then the demand of movies to be developed onto digital format rather than 35mm has increased drastically.

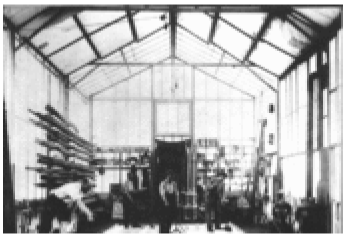
As digital technology improved, movie studios began increasingly shifting towards digital cinematography. Since the 2010s, digital cinematography has become the dominant form of cinematography after largely superseding film cinematography.

Aspects

Main article: Cinematic techniques

Numerous aspects contribute to the art of cinematography, including:

Cinema technique



Georges Méliès (left) painting a backdrop in his studio

The first film cameras were fastened directly to the head of a tripod or other support, with only the crudest kind of leveling devices provided, in the manner of the still-camera tripod heads of the period. The earliest film cameras were thus effectively fixed during the shot, and hence the first camera movements were the result of mounting a camera on a moving vehicle. The first known of these was a film shot by a Lumière cameraman from the back platform of a train leaving Jerusalem in 1896, and by 1898, there were a number of films shot from moving trains. Although listed under the general heading of "panoramas" in the sales catalogues of the time, those films shot straight forward from in front of a railway engine were usually specifically referred to as "phantom rides".

In 1897, Robert W. Paul had the first real rotating camera head made to put on a tripod, so that he could follow the passing processions of Queen Victoria's Diamond Jubilee in one uninterrupted shot. This device had the camera mounted on a vertical axis that could be rotated by a worm gear driven by turning a crank handle, and Paul put it on general sale the next year. Shots taken using such a "panning" head were also referred to as "panoramas" in the film catalogues of the first decade of the cinema. This eventually led to the creation of a panoramic photo as well.

The standard pattern for early film studios was provided by the studio which Georges Méliès had built in 1897. This had a glass roof and three glass walls constructed after the model of large studios for still photography, and it was fitted with thin cotton cloths that could be stretched below the roof to diffuse the direct ray of the sun on sunny days. The soft overall light without real shadows that this arrangement produced, and which also exists naturally on lightly overcast days, was to become the basis for film lighting in film studios for the next decade.

Image sensor and film stock

Cinematography can begin with digital image sensor or rolls of film. Advancements in film emulsion and grain structure provided a wide range of available film stocks. The selection of a film stock is one of the first decisions made in preparing a typical film production.

Aside from the film gauge selection – 8 mm (amateur), 16 mm (semi-professional), 35 mm (professional) and 65 mm (epic photography, rarely used except in special event venues) – the cinematographer has a selection of stocks in reversal (which, when developed, create a positive image) and negative formats along with a wide range of film speeds (varying sensitivity to light) from ISO 50 (slow, least sensitive to light) to 800 (very fast, extremely sensitive to light) and differing response to color (low saturation, high saturation) and contrast (varying levels between pure black (no exposure) and pure white (complete overexposure). Advancements and adjustments to nearly all gauges of film create the "super" formats wherein the area of the film used to capture a single frame of an image is expanded, although the physical gauge of the film remains the same. Super 8 mm, Super 16 mm, and Super 35 mm all utilize more of the overall film area for the image than their "regular" non-super counterparts. The larger the film gauge, the higher the overall image resolution clarity and technical quality. The techniques used by the film laboratory to process the film stock can also offer a considerable variance in the image produced. By controlling the temperature and varying the duration in which the film is soaked in the development chemicals, and by skipping certain chemical processes (or partially skipping all of them), cinematographers can achieve very different looks from a single film stock in the laboratory. Some techniques that can be used are push processing, bleach bypass, and cross processing.

Most of modern cinema uses digital cinematography and has no film stocks[*citation needed*], but the cameras themselves can be adjusted in ways that go far beyond the abilities of one particular film stock. They can provide varying degrees of color sensitivity, image contrast, light sensitivity and so on. One camera can achieve all the various looks of different emulsions. Digital image adjustments such as ISO and contrast are executed by estimating the same adjustments that would take place if actual film were in use, and are thus vulnerable to the camera's sensor designers perceptions of various film stocks and image adjustment parameters.

Filters

Filters, such as diffusion filters or color effect filters, are also widely used to enhance mood or dramatic effects. Most photographic filters are made up of two pieces of optical glass glued together with some form of image or light manipulation material between the glass. In the case of color filters, there is often a translucent color medium pressed between two planes of optical glass. Color filters work by blocking out certain color wavelengths of light from reaching the film. With color film, this works very intuitively wherein a blue filter will cut down on the passage of red, orange, and yellow light and create a blue tint on the film. In black-and-white photography, color filters are used somewhat counter intuitively; for instance a yellow filter, which cuts down on blue wavelengths of light, can be used to darken a daylight sky (by eliminating blue light from hitting the film, thus greatly underexposing the mostly blue sky) while not biasing most human flesh tone. Certain cinematographers, such as Christopher Doyle, are well known for their innovative use of filters. Filters can be used in front of the lens or, in some cases, behind the lens for different effects. Christopher Doyle was a pioneer for increased usage of filters in movies. He was highly respected throughout the cinema world.

Lens

Lenses can be attached to the camera to give a certain look, feel, or effect by focus, color, etc.

As does the human eye, the camera creates perspective and spatial relations with the rest of the world. However, unlike one's eye, a cinematographer can select different lenses for different purposes. Variation in focal length is one of the chief benefits. The focal length of the lens determines the angle of view and, therefore, the field of view. Cinematographers can choose from a range of wide-angle lenses, "normal" lenses and long focus lenses, as well as macro lenses and other special effect lens systems such as borescope lenses. Wide-angle lenses have short focal lengths and make spatial distances more obvious. A person in the distance is shown as much smaller while someone in the front will loom large. On the other hand, long focus lenses reduce such exaggerations, depicting far-off objects as seemingly close together and flattening perspective. The differences between the perspective rendering is actually not due to the focal length by itself, but by the distance between the subjects and the camera. Therefore, the use of different focal lengths in combination with different camera to subject distances creates these different rendering. Changing the focal length only while keeping the same camera position doesn't affect perspective but the camera angle of view only.

A zoom lens allows a camera operator to change his focal length within a shot or quickly between setups for shots. As prime lenses offer greater optical quality and are "faster" (larger aperture openings, usable in less light) than zoom lenses, they are often employed in professional cinematography over zoom lenses. Certain scenes or even types of filmmaking, however, may require the use of zooms for speed or ease of use, as well as shots involving a zoom move.

As in other photography, the control of the exposed image is done in the lens with the control of the diaphragm aperture. For proper selection, the cinematographer needs that all lenses be engraved with T-stop, not f-stop so that the eventual light loss due to the glass doesn't affect the exposure control when setting it using the usual meters. The choice of the aperture also affects image quality (aberrations) and depth of field.

Depth of field and focus

A deep focus shot from *Citizen Kane* (1941): everything, including the hat in the foreground and the boy (young Charles Foster Kane) in the distance, is in sharp focus.

Focal length and diaphragm aperture affect the depth of field of a scene – that is, how much the background, mid-ground and foreground will be rendered in "acceptable focus" (only one exact plane of the image is in precise focus) on the film or video target. Depth of field (not to be confused with depth of focus) is determined by the aperture size and the focal distance. A large or deep depth of field is generated with a very small iris aperture and focusing on a point in the distance, whereas a shallow depth of field will be achieved with a large (open) iris aperture and focusing closer to the lens. Depth of field is also governed by the format size. If one considers the field of view and angle of view, the smaller the image is, the shorter the focal length should be, as to keep the same field of view. Then, the smaller the image is, the more depth of field is obtained, for the same field of view. Therefore, 70mm has less depth of field than 35mm for a given field of view, 16mm more than 35mm, and early video cameras, as well as most modern consumer level video cameras, even more depth of field than 16mm.

In *Citizen Kane* (1941), cinematographer Gregg Toland and director Orson Welles used tighter apertures to create every detail of the foreground and background of the sets in sharp focus. This practice is known as deep focus. Deep focus became a popular cinematographic device from the 1940s onwards in Hollywood. Today, the trend is for more shallow focus. To change the plane of focus from one object or character to another within a shot is commonly known as a *rack focus*.

Early in the transition to digital cinematography, the inability of digital video cameras to easily achieve shallow depth of field, due to their small image sensors, was initially an issue of frustration for film makers trying to emulate the look of 35mm film. Optical adapters were devised which accomplished this by mounting a larger format lens which projected its image, at the size of the larger format, on a ground glass screen preserving the depth of field. The adapter and lens then mounted on the small format video camera which in turn focused on the ground glass screen.

Digital SLR still cameras have sensor sizes similar to that of the 35mm film frame, and thus are able to produce images with similar depth of field. The advent of video functions in these cameras sparked a revolution in digital cinematography, with more and more film makers adopting still cameras for the purpose because of the film-like qualities of their images. More recently, more and more dedicated video cameras are being equipped with larger sensors capable of 35mm film-like depth of field.

Aspect ratio and framing

The aspect ratio of an image is the ratio of its width to its height. This can be expressed either as a ratio of 2 integers, such as 4:3, or in a decimal format, such as 1.33:1 or simply 1.33.

Different ratios provide different aesthetic effects. Standards for aspect ratio have varied significantly over time.

During the silent era, aspect ratios varied widely, from square 1:1, all the way up to the extreme widescreen 4:1 Polyvision. However, from the 1910s, silent motion pictures generally settled on the ratio of 4:3 (1.33). The introduction of sound-on-film briefly narrowed the aspect ratio, to allow room for a sound stripe. In 1932, a new standard was introduced, the Academy ratio of 1.37, by means of thickening the frame line.

For years, mainstream cinematographers were limited to using the Academy ratio, but in the 1950s, thanks to the popularity of Cinerama, widescreen ratios were introduced in an effort to pull audiences back into the theater and away from their home television sets. These new widescreen formats provided cinematographers a wider frame within which to compose their images.

Many different proprietary photographic systems were invented and utilized in the 1950s to create widescreen movies, but one dominated film: the anamorphic process, which optically squeezes the image to photograph twice the horizontal area to the same size vertical as standard "spherical" lenses. The first commonly used anamorphic format was CinemaScope, which used a 2.35 aspect ratio, although it was originally 2.55. CinemaScope was used from 1953 to 1967, but due to technical flaws in the design and its ownership by Fox, several third-party companies, led by Panavision's technical improvements in the 1950s, dominated the anamorphic cine lens market. Changes to SMPTE projection standards altered the projected ratio from 2.35 to 2.39 in 1970, although this did not change anything regarding the photographic anamorphic standards; all changes in respect to the aspect ratio of anamorphic 35 mm photography are specific to camera or projector gate sizes, not the optical system. After the "widescreen wars" of the 1950s, the motion-picture industry settled into 1.85 as a standard for theatrical projection in the United States and the United Kingdom. This is a cropped version of 1.37. Europe and Asia opted for 1.66 at first, although 1.85 has largely permeated these markets in recent decades. Certain "epic" or adventure movies utilized the anamorphic 2.39.

In the 1990s, with the advent of high-definition video, television engineers created the 1.78 (16:9) ratio as a mathematical compromise between the theatrical standard of 1.85 and television's 1.33, as it was not practical to produce a traditional CRT television tube with a width of 1.85. Until that point, nothing had ever been originated in 1.78. Today, this is a standard for high-definition video and for widescreen television.

Lighting

Light is necessary to create an image exposure on a frame of film or on a digital target (CCD, etc.). The art of lighting for cinematography goes far beyond basic exposure, however, into the essence of visual storytelling. Lighting contributes considerably to the emotional response an audience has watching a motion picture. The increased usage of filters can greatly impact the final image and affect the lighting.

Camera movement

[Play media]

Camera on a small motor vehicle representing a large one

Cinematography can not only depict a moving subject but can use a camera, which represents the audience's viewpoint or perspective, that moves during the course of filming. This movement plays a considerable role in the emotional language of film images and the audience's emotional reaction to the action. Techniques range from the most basic movements of panning (horizontal shift in viewpoint from a fixed position; like turning your head side-to-side) and tilting (vertical shift in viewpoint from a fixed position; like tipping your head back to look at the sky or down to look at the ground) to dollying (placing the camera on a moving platform to move it closer or farther from the subject), tracking (placing the camera on a moving platform to move it to the left or right), craning (moving the camera in a vertical position; being able to lift it off the ground as well as swing it side-to-side from a fixed base position), and combinations of the above. Early cinematographers often faced problems that were not common to other graphic artists because of the element of motion.[12]

Live filming for TV (2013)

Cameras have been mounted to nearly every imaginable form of transportation.

Most cameras can also be handheld, that is held in the hands of the camera operator who moves from one position to another while filming the action. Personal stabilizing platforms came into being in the late 1970s through the invention of Garrett Brown, which became known as the Steadicam. The Steadicam is a body harness and stabilization arm that connects to the camera, supporting the camera while isolating it from the operator's body movements. After the Steadicam patent expired in the early 1990s, many other companies began manufacturing their concept of the personal camera stabilizer. This invention is much more common throughout the cinematic world today. From feature-length films to the evening news, more and more networks have begun to use a personal camera stabilizer.

Special effects

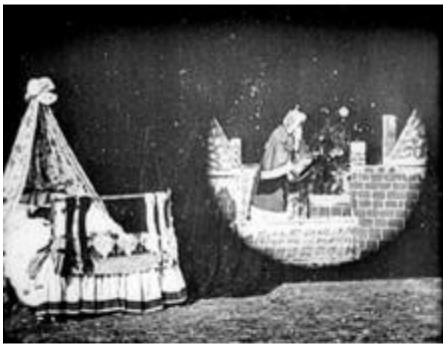
Main article: Special effect

The first special effects in the cinema were created while the film was being shot. These came to be known as "in-camera" effects. Later, optical and digital effects were developed so that editors and visual effects artists could more tightly control the process by manipulating the film in post-production.

The 1896 movie The Execution of Mary Stuart shows an actor dressed as the queen placing her head on the execution block in front of a small group of bystanders in Elizabethan dress. The executioner brings his axe down, and the queen's severed head drops onto the ground. This trick was worked by stopping the camera and replacing the actor with a dummy, then restarting the camera before the axe falls. The two pieces of film were then trimmed and cemented together so that the action appeared continuous when the film was shown, thus creating an overall illusion and successfully laying the foundation for special effects.

This film was among those exported to Europe with the first Kinetoscope machines in 1895 and was seen by Georges Méliès, who was putting on magic shows in his Theatre Robert-Houdin in Paris at the time. He took up filmmaking in 1896, and after making imitations of other films from Edison, Lumière, and Robert Paul, he made *Escamotage d'un dame chez Robert-Houdin (The Vanishing Lady)*. This film shows a woman being made to vanish by using the same stop motion technique as the earlier Edison film. After this, Georges Méliès made many single shot films using this trick over the next couple of years.

Double exposure



A scene inset inside a circular vignette showing a "dream vision" in *Santa Claus* (1898).

The other basic technique for trick cinematography involves double exposure of the film in the camera, which was first done by George Albert Smith in July 1898 in the UK. Smith's *The Corsican Brothers* (1898) was described in the catalogue of the Warwick Trading Company, which took up the distribution of Smith's films in 1900, thus:

"One of the twin brothers returns home from shooting in the Corsican mountains, and is visited by the ghost of the other twin. By extremely careful photography the ghost appears *quite transparent*. After indicating that he has been killed by a sword-thrust, and appealing for vengeance, he disappears. A 'vision' then appears showing the fatal duel in the snow. To the Corsican's amazement, the duel and death of his brother are vividly depicted in the vision, and overcome by his feelings, he falls to the floor just as his mother enters the room."

The ghost effect was done by draping the set in black velvet after the main action had been shot, and then re-exposing the negative with the actor playing the ghost going through the actions at the appropriate point. Likewise, the vision, which appeared within a circular vignette or matte, was similarly superimposed over a black area in the backdrop to the scene, rather than over a part of the set with detail in it, so that nothing appeared through the image, which seemed quite solid. Smith used this technique again in *Santa Claus* (1898).

Georges Méliès first used superimposition on a dark background in *La Caverne maudite (The Cave of the Demons)* made a couple of months later in 1898, and elaborated it with multiple superimpositions in the one shot in *Un Homme de têtes* (*The Four Troublesome Heads*). He created further variations in subsequent films.

Frame rate selection

Main article: Frame rate

Motion picture images are presented to an audience at a constant speed. In the theater it is 24 frames per second, in NTSC (US) Television it is 30 frames per second (29.97 to be exact), in PAL (Europe) television it is 25 frames per second. This speed of presentation does not vary.

However, by varying the speed at which the image is captured, various effects can be created knowing that the faster or slower recorded image will be played at a constant speed. Giving the cinematographer even more freedom for creativity and expression to be made.

For instance, time-lapse photography is created by exposing an image at an extremely slow rate. If a cinematographer sets a camera to expose one frame every minute for four hours, and then that footage is projected at 24 frames per second, a four-hour event will take 10 seconds to present, and one can present the events of a whole day (24 hours) in just one minute.

The inverse of this, if an image is captured at speeds above that at which they will be presented, the effect is to greatly slow down (slow motion) the image. If a cinematographer shoots a person diving into a pool at 96 frames per second, and that image is played back at 24 frames per second, the presentation will take 4 times as long as the actual event. Extreme slow motion, capturing many thousands of frames per second can present things normally invisible to the human eye, such as bullets in flight and shockwaves travelling through media, a potentially powerful cinematographical technique.

In motion pictures, the manipulation of time and space is a considerable contributing factor to the narrative storytelling tools. Film editing plays a much stronger role in this manipulation, but frame rate selection in the photography of the original action is also a contributing factor to altering time. For example, Charlie Chaplin's *Modern Times* was shot at "silent speed" (18 fps) but projected at "sound speed" (24 fps), which makes the slapstick action appear even more frenetic.

Speed ramping, or simply "ramping", is a process whereby the capture frame rate of the camera changes over time. For example, if in the course of 10 seconds of capture, the capture frame rate is adjusted from 60 frames per second to 24 frames per second, when played back at the standard movie rate of 24 frames per second, a unique time-manipulation effect is achieved. For example, someone pushing a door open and walking out into the street would appear to start off in slow-motion, but in a few seconds later within the same shot, the person would appear to walk in "realtime" (normal speed). The opposite speed-ramping is done in *The Matrix* when Neo re-enters the Matrix for the first time to see the Oracle. As he comes out of the warehouse "load-point", the camera zooms into Neo at normal speed but as it gets closer to Neo's face, time seems to slow down, foreshadowing the manipulation of time itself within the Matrix later in the movie.

Other special techniques

G. A. Smith initiated the technique of reverse motion and also improved the quality of self-motivating images. This he did by repeating the action a second time while filming it with an inverted camera and then joining the tail of the second negative to that of the first. The first films using this were *Tipsy, Topsy, Turvy* and *The Awkward Sign Painter*, the latter which showed a sign painter lettering a sign, and then the painting on the sign vanishing under the painter's brush. The earliest surviving example of this technique is Smith's *The House That Jack Built*, made before September 1901. Here, a small boy is shown knocking down a castle just constructed by a little girl out of children's building blocks. A title then appears, saying "Reversed", and the action is repeated in reverse so that the castle re-erects itself under his blows.

Cecil Hepworth improved upon this technique by printing the negative of the forwards motion backwards frame by frame, so that in the production of the print the original action was exactly reversed. Hepworth made *The Bathers* in 1900, in which bathers who have undressed and jumped into the water appear to spring backwards out of it, and have their clothes magically fly back onto their bodies.

The use of different camera speeds also appeared around 1900. Robert Paul's *On a Runaway Motor Car through Piccadilly Circus* (1899), had the camera turn so slowly that when the film was projected at the usual 16 frames per second, the scenery appeared to be passing at great speed. Cecil Hepworth used the opposite effect in *The Indian Chief and the Seidlitz powder* (1901), in which a naïve Red Indian eats a lot of the fizzy stomach medicine, causing his stomach to expand and then he then leaps around balloon-like. This was done by cranking the camera faster than the normal 16 frames per second giving the first "slow motion" effect.

Personnel

A camera crew from the First Motion Picture Unit

In descending order of seniority, the following staff is involved:

- **Director of photography** also called **cinematographer**
- **Camera operator** also called **cameraman**
- **First assistant camera** also called **focus puller**
- **Second assistant camera** also called **clapper loader**

In the film industry, the **cinematographer** is responsible for the technical aspects of the images (lighting, lens choices, composition, exposure, filtration, film selection), but works closely with the director to ensure that the artistic aesthetics are supporting the director's vision of the story being told. The cinematographers are the heads of the camera, grip and lighting crew on a set, and for this reason, they are often called **directors of photography** or **DPs**. The ASC defines cinematography as a creative and interpretive process that culminates in the authorship of an original work of art rather than the simple recording of a physical event. Cinematography is not a subcategory of photography. Rather, photography is but one craft that the cinematographer uses in addition to other physical, organizational, managerial, interpretive. and image-manipulating techniques to effect one coherent process.[13] In British tradition, if the DOP actually operates the camera him/herself they are called the *cinematographer*. On smaller productions, it is common for one person to perform all these functions alone. The career progression usually involves climbing up the ladder from seconding, firsting, eventually to operating the camera.

Directors of photography make many creative and interpretive decisions during the course of their work, from pre-production to post-production, all of which affect the overall feel and look of the motion picture. Many of these decisions are similar to what a photographer needs to note when taking a picture: the cinematographer controls the film choice itself (from a range of available stocks with varying sensitivities to light and color), the selection of lens focal lengths, aperture exposure and focus. Cinematography, however, has a temporal aspect (see persistence of vision), unlike still photography, which is purely a single still image. It is also bulkier and more strenuous to deal with movie cameras, and it involves a more complex array of choices. As such a cinematographer often needs to work co-operatively with more people than does a photographer, who could frequently function as a single person. As a result, the cinematographer's job also includes personnel management and logistical organization. Given the in-depth knowledge. a cinematographer requires not only of his or her own craft but also that of other personnel, formal tuition in analogue or digital filmmaking can be advantageous.[14]

Elements of Cinematography

1. **Human Eye**
2. **Intro to Cinematography**
3. **Exposure**
   - Aperture / F-Stop
   - Shutter Speed
4. **Shot Sizes**
5. **Camera Angles**
6. **Camera Moves**
7. **Composition**
8. **Types of Lenses**
9. **Depth of Field (DoF)**
10. **White Balance**

References

Sr.No	Title	Author	Publisher	Edition	Year of Edition
1	Cinematogrphy	David Mullen	-	-	-
2	Cinematogrphy Motion Picture Filming Techniqes	Kindle Edition	-	-	-
3	Cinematogrphy Theory & Practice	Blain Brown	-	-	-
4	Spealling of Films	Satyajit Ray	-	-	-
5	Filmmaker Handbook	Steven Ascher	-	-	
6	Read a Film	James Monoco	-	-	-

PAPER VI **Lighting & Rendering** 50Hrs.

Course Type: Theory / Practical	Theory
Required/Elective	Required
Prerequisite	2D animation & 3D animation
Teaching Scheme (Lecture/Practical/Tutorial/Drawing)	02/02/00/00 Hours
Total contact Hours (Lecture/Practical/Tutorial/Drawing)	50/00/00/00 Hours
EvaluationScheme: Theory **Theory Paper /Term Work/Oral/Practical**	--/--/--/--

Course Outcomes (COs):

Course Outcomes(COs): Upon completion of this course, students will be able to		Mapping with PO's
CO107.1	Understand the use of appropriate lamps and lighting techniques as an energy saving tool.	4,9
CO107.2	Understand the importance of optical control in the selection of lamps, fixtures, and lighting techniques.	4,7
CO107.3	Create an accurately drawn lighting plan that demonstrates an understanding of the application of a variety of lighting techniques to meet function and design criteria.	5,7
CO107.4	Utilize appropriate drafting symbols to convey lighting design solutions. Create a lighting fixture schedule.	5
CO107.5	Upon successful completion of the course, the student will have a good grasp of design as it applies to their forms and animation	2,9
CO107.6	identify good and bad composition & staging; identify and build an emotional impact using color, light, and camera perspective within a scene; create and use technical drawings to build models; create surfaces and lighting set-ups that strengthen the overall project design;	1,2,7

Correlation matrix of Course outcomes with Programmed outcomes (CO-PO)
1=Low correlation, 2=Medium correlation, 3=High correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2
CO107.1	-	-	-	3	-	-	-	-	2	-	2
CO107.2	-	-	-	3	1	-	2	-	-	-	2
CO107.3	-	-	-	-	3	-	2	-	-	-	2
CO107.4	-	-	-	-	3	-	-	-	-	-	2
CO107.5	-	2	-	-	-	-	-	-		-	2
CO107.6	1	2	-	-	-	-	-	-	3	-	1,2

Lighting

"Artificial light" redirects here. For the song, see Artificial Light (song). For simulated 3D lighting, see Computer graphics lighting.

Illuminated cherry blossoms, light from the shop windows, and Japanese lantern at night in Ise, Mie, Japan

Daylight used at the train station Gare de l'Est Paris

Low-intensity lighting and haze in a concert hall allows laser effects to be visible

Lighting or **illumination** is the deliberate use of light to achieve a practical or aesthetic effect. Lighting includes the use of both artificial light sources like lamps and light fixtures, as well as natural illumination by capturing daylight. Daylighting (using windows, skylights, or light shelves) is sometimes used as the main source of light during daytime in buildings. This can save energy in place of using artificial lighting, which represents a major component of energy consumption in buildings. Proper lighting can enhance task performance, improve the appearance of an area, or have positive psychological effects on occupants.

Indoor lighting is usually accomplished using light fixtures, and is a key part of interior design. Lighting can also be an intrinsic component of landscape projects.

Contents

History

With the discovery of fire, the earliest form of artificial lighting used to illuminate an area were campfires or torches. As early as 400,000 BCE, fire was kindled in the caves of Peking

Man. Prehistoric people used primitive oil lamps to illuminate surroundings. These lamps were made from naturally occurring materials such as rocks, shells, horns and stones, were filled with grease, and had a fiber wick. Lamps typically used animal or vegetable fats as fuel. Hundreds of these lamps (hollow worked stones) have been found in the Lascaux caves in modern-day France, dating to about 15,000 years ago. Oily animals (birds and fish) were also used as lamps after being threaded with a wick. Fireflies have been used as lighting sources. Candles and glass and pottery lamps were also invented.[1] Chandeliers were an early form of "light fixture".

A major reduction in the cost of lighting occurred with the discovery of whale oil.[2] The use of whale oil declined after Abraham Gesner, a Canadian geologist, first refined kerosene in the 1840s, allowing brighter light to be produced at substantially lower cost.[3] In the 1850s, the price of whale oil dramatically increased (more than doubling from 1848 to 1856) due to shortages of available whales, hastening whale oil's decline.[3] By 1860, there were 33 kerosene plants in the United States, and Americans spent more on gas and kerosene than on whale oil.[3] The final death knell for whale oil was in 1859, when crude oil was discovered and the petroleum industry arose.[3]

Gas lighting was economical enough to power street lights in major cities starting in the early 1800s, and was also used in some commercial buildings and in the homes of wealthy people. The gas mantle boosted the luminosity of utility lighting and of kerosene lanterns. The next major drop in price came about in the 1880s with the introduction of electric lighting in the form of arc lights for large space and street lighting followed on by incandescent light bulb based utilities for indoor and outdoor lighting.[2][4]

Over time, electric lighting became ubiquitous in developed countries.[5] Segmented sleep patterns disappeared, improved nighttime lighting made more activities possible at night, and more street lights reduced urban crime.[6][7][8]

Fixtures

Main article: Light fixture

Lighting fixtures come in a wide variety of styles for various functions. The most important functions are as a holder for the light source, to provide directed light and to avoid visual glare. Some are very plain and functional, while some are pieces of art in themselves. Nearly any material can be used, so long as it can tolerate the excess heat and is in keeping with safety codes.

An important property of light fixtures is the luminous efficacy or wall-plug efficiency, meaning the amount of usable light emanating from the fixture per used energy, usually measured in lumen per watt. A fixture using replaceable light sources can also have its efficiency quoted as the percentage of light passed from the "bulb" to the surroundings. The more transparent the lighting fixture is, the higher efficacy. Shading the light will normally decrease efficacy but increase the directionality and the visual comfort probability.

Color temperature for white light sources also affects their use for certain applications. The color temperature of a white light source is the temperature in kelvins of a theoretical black body emitter that most closely matches the spectral characteristics of the lamp. An incandescent bulb has a color temperature around 2800 to 3000 kelvins; daylight is around 6400 kelvins. Lower color temperature lamps have relatively more energy in the yellow and red part of the visible spectrum, while high color temperatures correspond to lamps with more of a blue-white appearance. For critical inspection or color matching tasks, or for retail displays of food and clothing, the color temperature of the lamps will be selected for the best overall lighting effect.

Types

See also: List of types of lighting

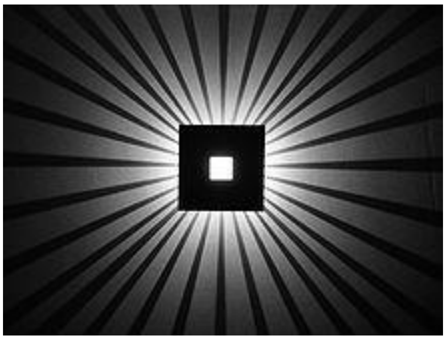
A demonstration of the effects of different kinds of lighting

Lighting is classified by intended use as general, accent, or task lighting, depending largely on the distribution of the light produced by the fixture.

- Task lighting is mainly functional and is usually the most concentrated, for purposes such as reading or inspection of materials. For example, reading poor-quality reproductions may require task lighting levels up to 1500 lux (150 footcandles), and some inspection tasks or surgical procedures require even higher levels.
- Accent lighting is mainly decorative, intended to highlight pictures, plants, or other elements of interior design or landscaping.
- General lighting (sometimes referred to as ambient light) fills in between the two and is intended for general illumination of an area. Indoors, this would be a basic lamp on a table or floor, or a fixture on the ceiling. Outdoors, general lighting for a parking lot may be as low as 10-20 lux (1-2 footcandles) since pedestrians and motorists already used to the dark will need little light for crossing the area.

Methods

- Downlighting is most common, with fixtures on or recessed in the ceiling casting light downward. This tends to be the most used method, used in both offices and homes. Although it is easy to design it has dramatic problems with glare and excess energy consumption due to large number of fittings.[9] The introduction of LED lighting has greatly improved this by approx. 90% when compared to a halogen downlight or spotlight. LED lamps or bulbs are now available to retro fit in place of high energy consumption lamps.
- Uplighting is less common, often used to bounce indirect light off the ceiling and back down. It is commonly used in lighting applications that require minimal glare and uniform general illuminance levels. Uplighting (indirect) uses a diffuse surface to reflect light in a space and can minimize disabling glare on computer displays and other dark glossy surfaces. It gives a more uniform presentation of the light output in operation. However indirect lighting is completely reliant upon the reflectance value of the surface. While indirect lighting can create a diffused and shadow free light effect it can be regarded as an uneconomical lighting principle.[10][11]
- Front lighting is also quite common, but tends to make the subject look flat as its casts almost no visible shadows. Lighting from the side is the less common, as it tends to produce glare near eye level. Backlighting either around or through an object is mainly for accent.



Wall-mounted light with shadows

Forms of lighting

Indoor lighting

Forms of lighting include alcove lighting, which like most other uplighting is indirect. This is often done with fluorescent lighting (first available at the 1939 World's Fair) or rope light, occasionally with neon lighting, and recently with LED strip lighting. It is a form of backlighting.

Soffit or close to wall lighting can be general or a decorative wall-wash, sometimes used to bring out texture (like stucco or plaster) on a wall, though this may also show its defects as well. The effect depends heavily on the exact type of lighting source used.

Recessed lighting (often called "pot lights" in Canada, "can lights" or 'high hats" in the US) is popular, with fixtures mounted into the ceiling structure so as to appear flush with it. These downlights can use narrow beam spotlights, or wider-angle floodlights, both of which are bulbs having their own reflectors. There are also downlights with internal reflectors designed to accept common 'A' lamps (light bulbs) which are generally less costly than reflector lamps. Downlights can be incandescent, fluorescent, HID (high intensity discharge) or LED.

Track lighting, invented by Lightolier,[12] was popular at one period of time because it was much easier to install than recessed lighting, and individual fixtures are decorative and can be easily aimed at a wall. It has regained some popularity recently in low-voltage tracks, which often look nothing like their predecessors because they do not have the safety issues that line-voltage systems have, and are therefore less bulky and more ornamental in themselves. A master transformer feeds all of the fixtures on the track or rod with 12 or 24 volts, instead of each light fixture having its own line-to-low voltage transformer. There are traditional spots and floods, as well as other small hanging fixtures. A modified version of this is cable lighting, where lights are hung from or clipped to bare metal cables under tension.

A sconce is a wall-mounted fixture, particularly one that shines up and sometimes down as well. A torchère is an uplight intended for ambient lighting. It is typically a floor lamp but may be wall-mounted like a sconce. Further interior light fixtures include chandeliers, pendant lights, ceiling fans with lights, close-to-ceiling or flush lights, and various types of lamps[13]

The portable or table lamp is probably the most common fixture, found in many homes and offices. The standard lamp and shade that sits on a table is general lighting, while the desk lamp is considered task lighting. Magnifier lamps are also task lighting.

Animated fountain in Moscow's Square of Europe, lit at night.

The illuminated ceiling was once popular in the 1960s and 1970s but fell out of favor after the 1980s. This uses diffuser panels hung like a suspended ceiling below fluorescent lights, and is considered general lighting. Other forms include neon, which is not usually intended to illuminate anything else, but to actually be an artwork in itself. This would probably fall under accent lighting, though in a dark nightclub it could be considered general lighting.

In a movie theater, steps in the aisles are usually marked with a row of small lights for convenience and safety, when the film has started and the other lights are off. Traditionally made up of small low wattage, low voltage lamps in a track or translucent tube, these are rapidly being replaced with LED based versions.

Outdoor lighting

High mast lighting along Highway 401 in Ontario, Canada.

Street Lights are used to light roadways and walkways at night. Some manufacturers are designing LED and photovoltaic luminaires to provide an energy-efficient alternative to traditional street light fixtures.[14][15][16]

Floodlights are used to illuminate outdoor playing fields or work zones during nighttime.

Floodlights can be used to illuminate work zones[17] or outdoor playing fields during nighttime hours.[18][19] The most common type of floodlights are metal halide and high pressure sodium lights.

Beacon lights are positioned at the intersection of two roads to aid in navigation.

Sometimes security lighting can be used along roadways in urban areas, or behind homes or commercial facilities. These are extremely bright lights used to deter crime. Security lights may include floodlights.

Entry lights can be used outside to illuminate and signal the entrance to a property.[20] These lights are installed for safety, security, and for decoration.

Underwater accent lighting is also used for koi ponds, fountains, swimming pools and the like.

Vehicle use

Main article: Automotive lighting

Vehicles typically include headlamps and tail lights. Headlamps are white or selective yellow lights placed in the front of the vehicle, designed to illuminate the upcoming road and to make the vehicle more visible. Many manufactures are turning to LED headlights as an energy-efficient alternative to traditional headlamps.[21] Tail and brake lights are red and emit light to the rear so as to reveal the vehicle's direction of travel to following drivers. White rear-facing reversing lamps indicate that the vehicle's transmission has been placed in the reverse gear, warning anyone behind the vehicle that it is moving backwards, or about to do so. Flashing turn signals on the front, side, and rear of the vehicle indicate an intended change of position or direction. In the late 1950s, some automakers began to use electroluminescent technology to backlight their cars' speedometers and other gauges or to draw attention to logos or other decorative elements.

Lamps

Main article: Lamp (electrical component)

Commonly called 'light bulbs', lamps are the removable and replaceable part of a light fixture, which converts electrical energy into electromagnetic radiation. While lamps have traditionally been rated and marketed primarily in terms of their power consumption, expressed in watts, proliferation of lighting technology beyond the incandescent light bulb has eliminated the correspondence of wattage to the amount of light produced. For example, a 60 W incandescent light bulb produces about the same amount of light as a 13 W compact fluorescent lamp. Each of these technologies has a different efficacy in converting electrical energy to visible light. Visible light output is typically measured in lumens. This unit only quantifies the visible radiation, and excludes invisible infrared and ultraviolet light. A wax candle produces on the close order of 13 lumens, a 60 watt incandescent lamp makes around 700 lumens, and a 15-watt compact fluorescent lamp produces about 800 lumens, but actual output varies by specific design.[22] Rating and marketing emphasis is shifting away from wattage and towards lumen output, to give the purchaser a directly applicable basis upon which to select a lamp.

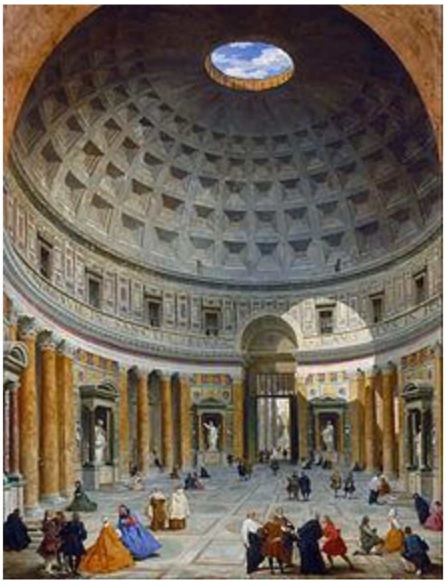
Lamp types include:

- Ballast: A ballast is an auxiliary piece of equipment designed to start and properly control the flow of power to discharge light sources such as fluorescent and high intensity discharge (HID) lamps. Some lamps require the ballast to have thermal protection.
- fluorescent light: A tube coated with phosphor containing low pressure mercury vapor that produces white light.
- Halogen: Incandescent lamps containing halogen gases such as iodine or bromine, increasing the efficacy of the lamp versus a plain incandescent lamp.
- Neon: A low pressure gas contained within a glass tube; the color emitted depends on the gas.
- Light emitting diodes: Light emitting diodes (LED) are solid state devices that emit light by dint of the movement of electrons in a semiconductor material.[23]
- Compact fluorescent lamps: CFLs are designed to replace incandescent lamps in existing and new installations.[24][25]

Design and architecture

Architectural lighting design

Main article: Architectural lighting design



Lighting without windows: The Pantheon in the 18th century, painted by Giovanni Paolo Panini.[26]

Lighting design as it applies to the built environment is known as 'architectural lighting design'. Lighting of structures considers aesthetic elements as well as practical considerations of quantity of light required, occupants of the structure, energy efficiency and cost. Artificial lighting takes into account the amount of daylight received in an internal space by using Daylight factor calculation. For simple installations, hand-calculations based on tabular data are used to provide an acceptable lighting design. More critical or optimized designs now routinely use mathematical modeling on a computer using software such as Radiance which can allow an Architect to quickly undertake complex calculations to review the benefit of a particular design.

In some design instances, materials used on walls and furniture play a key role in the lighting effect< for example dark paint tends to absorb light, making the room appear smaller and more dim than it is, whereas light paint does the opposite. In addition to paint, reflective surfaces also have an effect on lighting design.[11][27]

Photometric studies

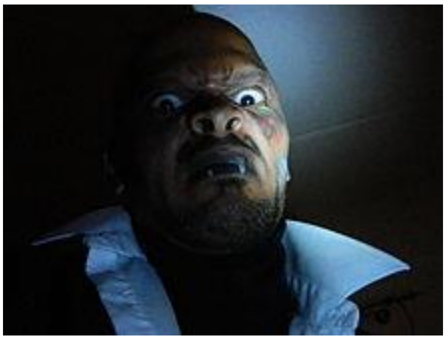
Photometric studies (also sometimes referred to as "layouts" or "point by points") are often used to simulate lighting designs for projects before they are built or renovated. This enables architects, designers, and engineers to determine which configuration of lighting fixtures will deliver the amount of light needed. Other parameters that can be determined are the contrast ratio between light and dark areas. In many cases these studies are referenced against IESNA or CIBSE recommended practices for the type of application. Depending on the building type, client, or safety requirements, different design aspects may be emphasized for safety or practicality. Specialized software is often used to create these, which typically combine the use of two-dimensional CAD drawings and lighting calculation software (i.e. AGi32, Visual, Dialux).

On stage and set

Main article: Stage lighting

Lighting and shadows

Moving heads in a photo studio set.



Illuminating subject from beneath to achieve a heightened dramatic effect.

Lighting illuminates the performers and artists in a live theatre, dance, or musical performance, and is selected and arranged to create dramatic effects. Stage lighting uses general illumination technology in devices configured for easy adjustment of their output characteristics.[*citation needed*] The setup of stage lighting is tailored for each scene of each production. Dimmers, colored filters, reflectors, lenses, motorized or manually aimed lamps, and different kinds of flood and spot lights are among the tools used by a stage lighting designer to produce the desired effects. A set of lighting cues are prepared so that the lighting operator can control the lights in step with the performance; complex theatre lighting systems use computer control of lighting instruments.

Motion picture and television production use many of the same tools and methods of stage lighting. Especially in the early days of these industries, very high light levels were required and heat produced by lighting equipment presented substantial challenges. Modern cameras require less light, and modern light sources emit less heat.

Measurement

Main article: Photometry (optics)

Measurement of light or photometry is generally concerned with the amount of useful light falling on a surface and the amount of light emerging from a lamp or other source, along with the colors that can be rendered by this light. The human eye responds differently to light from different parts of the visible spectrum, therefore photometric measurements must take the luminosity function into account when measuring the amount of useful light. The basic SI unit of measurement is the candela (cd), which describes the luminous intensity, all other photometric units are derived from the candela. Luminance for instance is a measure of the density of luminous intensity in a given direction. It describes the amount of light that passes through or is emitted from a particular area, and falls within a given solid angle. The SI unit for luminance is candela per square metre (cd/m^2). The CGS unit of luminance is the stilb, which is equal to one candela per square centimetre or 10 kcd/m^2. The amount of useful light emitted from a source or the luminous flux is measured in lumen (lm).

The SI unit of illuminance and luminous emittance, being the luminous power per area, is measured in Lux. It is used in photometry as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface. It is analogous to the radiometric unit watts per square metre, but with the power at each wavelength weighted according to the luminosity function, a standardized model of human visual brightness perception. In English, "lux" is used in both singular and plural.[28]

Several measurement methods have been developed to control glare resulting from indoor lighting design. The Unified Glare Rating (UGR), the Visual Comfort Probability, and the Daylight Glare Index are some of the most well-known methods of measurement. In addition to these new methods, four main factors influence the degree of discomfort glare; the luminance of the glare source, the solid angle of the glare source, the background luminance, and the position of the glare source in the field of view must all be taken into account.[10][29]

Color properties

To define light source color properties, the lighting industry predominantly relies on two metrics, correlated color temperature (CCT), commonly used as an indication of the apparent "warmth" or "coolness" of the light emitted by a source, and color rendering index (CRI), an indication of the light source's ability to make objects appear natural.

However, these two metrics, developed in the last century, are facing increased challenges and criticisms as new types of light sources, particularly light emitting diodes (LEDs), become more prevalent in the market.

For example, in order to meet the expectations for good color rendering in retail applications, research[30] suggests using the well-established CRI along with another metric called gamut area index (GAI). GAI represents the relative separation of object colors illuminated by a light source; the greater the GAI, the greater the apparent saturation or vividness of the object colors. As a result, light sources which balance both CRI and GAI are generally preferred over ones that have only high CRI or only high GAI.[31]

Light exposure

Typical measurements of light have used a Dosimeter. Dosimeters measure an individual's or an object's exposure to something in the environment, such as light dosimeters and ultraviolet dosimeters.

In order to specifically measure the amount of light entering the eye, personal circadian light meter called the Daysimeter has been developed.[32] This is the first device created to accurately measure and characterize light (intensity, spectrum, timing, and duration) entering the eye that affects the human body's clock.

The small, head-mounted device measures an individual's daily rest and activity patterns, as well as exposure to short-wavelength light that stimulates the circadian system. The device measures activity and light together at regular time intervals and electronically stores and logs its operating temperature. The Daysimeter can gather data for up to 30 days for analysis.[33]

Energy consumption

Several strategies are available to minimize energy requirements for lighting a building:

- Specification of illumination requirements for each given use area.
- Analysis of lighting quality to ensure that adverse components of lighting (for example, glare or incorrect color spectrum) are not biasing the design.
- Integration of space planning and interior architecture (including choice of interior surfaces and room geometries) to lighting design.
- Design of time of day use that does not expend unnecessary energy.
- Selection of fixture and lamp types that reflect best available technology for energy conservation.
- Training of building occupants to use lighting equipment in most efficient manner.
- Maintenance of lighting systems to minimize energy wastage.
- Use of natural light
    - Some big box stores were being built from 2006 on with numerous plastic bubble skylights, in many cases completely obviating the need for interior artificial lighting for many hours of the day.
    - In countries where indoor lighting of simple dwellings is a significant cost, "Moser lamps", plastic water-filled transparent drink bottles fitted through the roof, provide the equivalent of a 40- to 60-watt incandescent bulb each during daylight.[34]

- Load shedding can help reduce the power requested by individuals to the main power supply. Load shedding can be done on an individual level, at a building level, or even at a regional level.

Specification of illumination requirements is the basic concept of deciding how much illumination is required for a given task. Clearly, much less light is required to illuminate a hallway compared to that needed for a word processing work station. Generally speaking, the energy expended is proportional to the design illumination level. For example, a lighting level of 400 lux might be chosen for a work environment involving meeting rooms and conferences, whereas a level of 80 lux could be selected for building hallways.[35][36][37][38][39] If the hallway standard simply emulates the conference room needs, then much more energy will be consumed than is needed. Unfortunately, most of the lighting standards even today have been specified by industrial groups who manufacture and sell lighting, so that a historical commercial bias exists in designing most building lighting, especially for office and industrial settings.

Lighting control systems

Main article: Lighting control system

Lighting control systems reduce energy usage and cost by helping to provide light only when and where it is needed. Lighting control systems typically incorporate the use of time schedules, occupancy control, and photocell control (i.e.daylight harvesting). Some systems also support demand response and will automatically dim or turn off lights to take advantage of utility incentives. Lighting control systems are sometimes incorporated into larger building automation systems.

Many newer control systems are using wireless mesh open standards (such as ZigBee),[40] which provides benefits including easier installation (no need to run control wires) and interoperability with other standards-based building control systems (e.g. security).[41]

In response to daylighting technology, daylight harvesting systems have been developed to further reduce energy consumption. These technologies are helpful, but they do have their downfalls. Many times, rapid and frequent switching of the lights on and off can occur, particularly during unstable weather conditions or when daylight levels are changing around the switching illuminance. Not only does this disturb occupants, it can also reduce lamp life. A variation of this technology is the 'differential switching or dead-band' photoelectric control which has multiple illuminances it switches from so as not to disturb occupants as much.[9][42]

Occupancy sensors to allow operation for whenever someone is within the area being scanned can control lighting. When motion can no longer be detected, the lights shut off. Passive infrared sensors react to changes in heat, such as the pattern created by a moving person. The control must have an unobstructed view of the building area being scanned. Doors, partitions, stairways, etc. will block motion detection and reduce its effectiveness. The best applications for passive infrared occupancy sensors are open spaces with a clear view of the area being scanned. Ultrasonic sensors transmit sound above the range of human hearing and monitor the time it takes for the sound waves to return. A break in the pattern caused by any motion in the area triggers the control. Ultrasonic sensors can see around obstructions and are best for areas with cabinets and shelving, restrooms, and open areas requiring 360-degree coverage. Some occupancy sensors utilize both passive infrared and ultrasonic technology, but are usually more expensive. They can be used to control one lamp, one fixture or many fixtures.[43][44]

Daylighting

Main article: Daylighting

Daylighting is the oldest method of interior lighting. Daylighting is simply designing a space to use as much natural light as possible. This decreases energy consumption and costs, and requires less heating and cooling from the building. Daylighting has also been proven to have positive effects on patients in hospitals as well as work and school performance. Due to a lack of information that indicate the likely energy savings, daylighting schemes are not yet popular among most buildings.[9][45]

Solid-state lighting

Main article: Solid-state lighting

In recent years light emitting diodes (LEDs) are becoming increasingly efficient leading to an extraordinary increase in the use of solid state lighting. In many situations, controlling the light emission of LEDs may be done most effectively by using the principles of nonimaging optics.[46]

Health effects

Main articles: Full-spectrum light, Over-illumination, and Light effects on circadian rhythm

It is valuable to provide the correct light intensity and color spectrum for each task or environment. Otherwise, energy not only could be wasted but over-illumination can lead to adverse health and psychological effects.

Beyond the energy factors being considered, it is important not to over-design illumination, lest adverse health effects such as headache frequency, stress, and increased blood pressure be induced by the higher lighting levels. In addition, glare or excess light can decrease worker efficiency.[47]

Analysis of lighting quality particularly emphasizes use of natural lighting, but also considers spectral content if artificial light is to be used. Not only will greater reliance on natural light reduce energy consumption, but will favorably impact human health and performance. New studies have shown that the performance of students is influenced by the time and duration of daylight in their regular schedules. Designing school facilities to incorporate the right types of light at the right time of day for the right duration may improve student performance and well-being. Similarly, designing lighting systems that maximize the right amount of light at the appropriate time of day for the elderly may help relieve symptoms of Alzheimer's Disease. The human circadian system is entrained to a 24-hour light-dark pattern that mimics the earth's natural light/dark pattern. When those patterns are disrupted, they disrupt the natural circadian cycle. Circadian disruption may lead to numerous health problems including breast cancer, seasonal affective disorder, delayed sleep phase syndrome, and other ailments.[48][49]

A study conducted in 1972 and 1981, documented by Robert Ulrich, surveyed 23 surgical patients assigned to rooms looking out on a natural scene. The study concluded that patients assigned to rooms with windows allowing lots of natural light had shorter postoperative hospital stays, received fewer negative evaluative comments in nurses' notes, and took fewer potent analegesics than 23 matched patients in similar rooms with windows facing a brick wall. This study suggests that due to the nature of the scenery and daylight exposure was indeed healthier for patients as opposed to those exposed to little light from the brick wall. In addition to increased work performance, proper usage of windows and daylighting crosses the boundaries between pure aesthetics and overall health.[45][50]

Alison Jing Xu, assistant professor of management at the University of Toronto Scarborough and Aparna Labroo of Northwestern University conducted a series of studies analyzing the correlation between lighting and human emotion. The researchers asked participants to rate a number of things such as: the spiciness of chicken-wing sauce, the aggressiveness of a fictional character, how attractive someone was, their feelings about specific words, and the taste of two juices–all under different lighting conditions. In their study, they found that both positive and negative human emotions are felt more intensely in bright light. Professor Xu stated, "we found that on sunny days depression-prone people actually become more depressed." They also found that dim light makes people make more rational decisions and settle negotiations easier. In the dark, emotions are slightly suppressed. However, emotions are intensified in the bright light.[51][52][53][54]

Environmental issues

Compact fluorescent lamps

Compact fluorescent lamps (CFLs) use less power than an incandescent lamp to supply the same amount of light, however they contain mercury which is a disposal hazard. Due to the ability to reduce electricity consumption, many organizations encourage the adoption of CFLs. Some electric utilities and local governments have subsidized CFLs or provided them free to customers as a means of reducing electricity demand. For a given light output, CFLs use between one fifth and one quarter the power of an equivalent incandescent lamp. Unlike incandescent lamps CFLs need a little time to warm up and reach full brightness. Not all CFLs are suitable for dimming.

LED lamps

LED lamps have been advocated as the newest and best environmental lighting method.[55] According to the Energy Saving Trust, LED lamps use only 10% power compared to a standard incandescent bulb, where compact fluorescent lamps use 20% and energy saving halogen lamps 70%. The lifetime is also much longer — up to 50,000 hours. A downside is still the initial cost, which is higher than that of compact fluorescent lamps. Recent findings about the increased use of blue-white LEDs may be a policy mistake. The wide-scale adoption of LEDs will reap energy savings but the energy savings may be compromising human health and ecosystems.[56] The American Medical Association[57] warned on the use of high blue content white LEDs in street lighting, due to their higher impact on human health and environment, compared to low blue content light sources (e.g. High Pressure Sodium, PC amber LEDs, and low CCT LEDs).

Light pollution

Main article: Light pollution

Light pollution is a growing problem in reaction to excess light being given off by numerous signs, houses, and buildings. Polluting light is often wasted light involving unnecessary energy costs and carbon dioxide emissions. Light pollution is described as artificial light that is excessive or intrudes where it is not wanted. Well-designed lighting sends light only where it is needed without scattering it elsewhere. Poorly designed lighting can also compromise safety. For example, glare creates safety issues around buildings by causing very sharp shadows, temporarily blinding passersby making them vulnerable to would-be assailants.[58][59] The ecologic effects of artificial light have been documented. The World Health Organization in 2007 [60] issued a report that noted the effects of bright light on flora and fauna, sea turtle hatchlings, frogs during mating season and the migratory patterns of birds. The American Medical Association in 2012[61] issued a warning that extended exposure to light at night increases the risk of some cancers.[56] Two studies in Israel from 2008 have yielded some additional findings about a possible correlation between artificial light at night and certain cancers.[62]

Professional organizations

International

The International Commission on Illumination (CIE) is an international authority and standard defining organization on color and lighting. Publishing widely used standard metrics such as various CIE color spaces and the color rendering index.

The Illuminating Engineering Society of North America (IESNA), in conjunction with organizations like ANSI and ASHRAE, publishes guidelines, standards, and handbooks that allow categorization of the illumination needs of different built environments. Manufacturers of lighting equipment publish photometric data for their products, which defines the distribution of light released by a specific luminaire. This data is typically expressed in standardized form defined by the IESNA.

The International Association of Lighting Designers (IALD) is an organization which focuses on the advancement of lighting design education and the recognition of independent professional lighting designers. Those fully independent designers who meet the requirements for professional membership in the association typically append the abbreviation IALD to their name.

The Professional Lighting Designers Association (PLDA), formerly known as ELDA is an organisation focusing on the promotion of the profession of Architectural Lighting Design. They publish a monthly newsletter and organise different events throughout the world.

The National Council on Qualifications for the Lighting Professions (NCQLP) offers the Lighting Certification Examination which tests rudimentary lighting design principles. Individuals who pass this exam become ‘Lighting Certified’ and may append the abbreviation LC to their name. This certification process is one of three national (U.S.) examinations (the others are CLEP and CLMC) in the lighting industry and is open not only to designers, but to lighting equipment manufacturers, electric utility employees, etc.

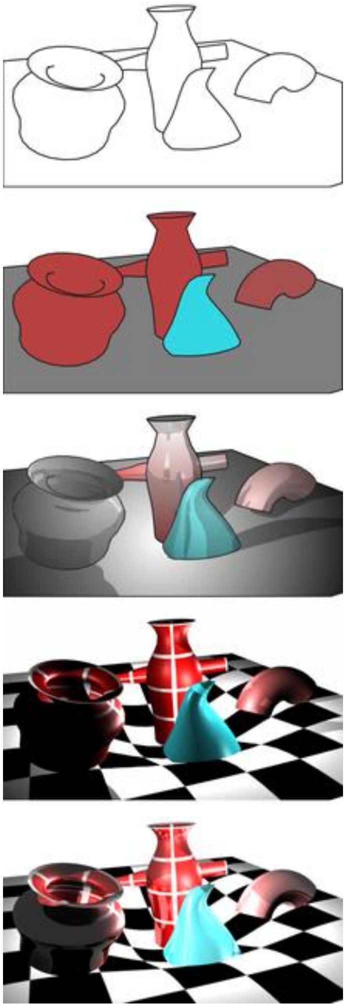
The Professional Lighting And Sound Association (PLASA) is a UK-based trade organisation representing the 500+ individual and corporate members drawn from the technical services sector. Its members include manufacturers and distributors of stage and entertainment lighting, sound, rigging and similar products and services, and affiliated professionals in the area. They lobby for and represent the interests of the industry at various levels, interacting with government and regulating bodies and presenting the case for the entertainment industry. Example subjects of this representation include the ongoing review of radio frequencies (which may or may not affect the radio bands in which wireless microphones and other devices use) and engaging with the issues surrounding the introduction of the RoHS (Restriction of Hazardous Substances Directive) regulations.

National

- [Association de Concepteurs Eclairage] (ACE) in France.
- Illuminating Engineering Society (IES) in United States.
- American Lighting Association (ALA) in United States.
- Associazione Professionisti dell'Illuminazione (APIL) in Italy.
- Hellenic Illumination Committee (HIC) in Greece.
- Indian Society of Lighting Engineers (ISLE)
- Institution of Lighting Engineers (ILE) in United Kingdom.
- Schweizerische Licht Gesellschaft (SLG) in Switzerland.
- Society of Light and Lighting (SLL), part of the Chartered Institution of Building Services Engineers in United Kingdom.
- United Scenic Artists Local 829 (USA829), membership for Lighting Designers as a category, with Scenic Designers, Projection Designers, Costume Designers, and Sound Designers, in the United States

Rendering

For 3-dimensional rendering, see 3D rendering. For rendering of HTML, see browser engine.



A variety of rendering techniques applied to a single 3D scene

An image created by using POV-Ray 3.6

Rendering or **image synthesis** is the automatic process of generating a photorealistic or non-photorealistic image from a 2D or 3D model (or models in what collectively could be called a *scene* file) by means of computer programs. Also, the results of displaying such a model can be called a **render**. A scene file contains objects in a strictly defined language or data structure; it would contain geometry, viewpoint, texture, lighting, and shading information as a description of the virtual scene. The data contained in the scene file is then passed to a rendering program to be processed and output to a digital image or raster graphics image file. The term "rendering" may be by analogy with an "artist's rendering" of a scene.

Though the technical details of rendering methods vary, the general challenges to overcome in producing a 2D image from a 3D representation stored in a scene file are outlined as the graphics pipeline along a rendering device, such as a GPU. A GPU is a purpose-built device able to assist a CPU in performing complex rendering calculations. If a scene is to look relatively realistic and predictable under virtual lighting, the rendering software should solve the rendering equation. The rendering equation doesn't account for all lighting phenomena, but is a general lighting model for computer-generated imagery. 'Rendering' is also used to describe the process of calculating effects in a video editing program to produce final video output.

Rendering is one of the major sub-topics of 3D computer graphics, and in practice is always connected to the others. In the graphics pipeline, it is the last major step, giving the final appearance to the models and animation. With the increasing sophistication of computer graphics since the 1970s, it has become a more distinct subject.

Rendering has uses in architecture, video games, simulators, movie or TV visual effects, and design visualization, each employing a different balance of features and techniques. As a product, a wide variety of renderers are available. Some are integrated into larger modeling and animation packages, some are stand-alone, some are free open-source projects. On the inside, a renderer is a carefully engineered program, based on a selective mixture of disciplines related to: light physics, visual perception, mathematics, and software development.

In the case of 3D graphics, rendering may be done slowly, as in pre-rendering, or in realtime. Pre-rendering is a computationally intensive process that is typically used for movie creation, while real-time rendering is often done for 3D video games which rely on the use of graphics cards with 3D hardware accelerators.

Contents

Usage

When the pre-image (a wireframe sketch usually) is complete, rendering is used, which adds in bitmap textures or procedural textures, lights, bump mapping and relative position to other objects. The result is a completed image the consumer or intended viewer sees.

For movie animations, several images (frames) must be rendered, and stitched together in a program capable of making an animation of this sort. Most 3D image editing programs can do this.

Features

A rendered image can be understood in terms of a number of visible features. Rendering research and development has been largely motivated by finding ways to simulate these efficiently. Some relate directly to particular algorithms and techniques, while others are produced together.

- Shading – how the color and brightness of a surface varies with lighting
- Texture-mapping – a method of applying detail to surfaces
- Bump-mapping – a method of simulating small-scale bumpiness on surfaces
- Fogging/participating medium – how light dims when passing through non-clear atmosphere or air
- Shadows – the effect of obstructing light
- Soft shadows – varying darkness caused by partially obscured light sources
- Reflection – mirror-like or highly glossy reflection
- Transparency (optics), transparency (graphic) or opacity – sharp transmission of light through solid objects
- Translucency – highly scattered transmission of light through solid objects
- Refraction – bending of light associated with transparency

- Diffraction – bending, spreading, and interference of light passing by an object or aperture that disrupts the ray
- Indirect illumination – surfaces illuminated by light reflected off other surfaces, rather than directly from a light source (also known as global illumination)
- Caustics (a form of indirect illumination) – reflection of light off a shiny object, or focusing of light through a transparent object, to produce bright highlights on another object
- Depth of field – objects appear blurry or out of focus when too far in front of or behind the object in focus
- Motion blur – objects appear blurry due to high-speed motion, or the motion of the camera
- Non-photorealistic rendering – rendering of scenes in an artistic style, intended to look like a painting or drawing

Techniques

Many rendering **algorithms** have been researched, and software used for rendering may employ a number of different techniques to obtain a final image.

Tracing every particle of light in a scene is nearly always completely impractical and would take a stupendous amount of time. Even tracing a portion large enough to produce an image takes an inordinate amount of time if the sampling is not intelligently restricted.

Therefore, a few loose families of more-efficient light transport modelling techniques have emerged:

- rasterization, including scanline rendering, geometrically projects objects in the scene to an image plane, without advanced optical effects;
- ray casting considers the scene as observed from a specific point of view, calculating the observed image based only on geometry and very basic optical laws of reflection intensity, and perhaps using Monte Carlo techniques to reduce artifacts;
- ray tracing is similar to ray casting, but employs more advanced optical simulation, and usually uses Monte Carlo techniques to obtain more realistic results at a speed that is often orders of magnitude faster.

The fourth type of light transport technique, radiosity is not usually implemented as a rendering technique, but instead calculates the passage of light as it leaves the light source and illuminates surfaces. These surfaces are usually rendered to the display using one of the other three techniques.

Most advanced software combines two or more of the techniques to obtain good-enough results at reasonable cost.

Another distinction is between image order algorithms, which iterate over pixels of the image plane, and object order algorithms, which iterate over objects in the scene. Generally object order is more efficient, as there are usually fewer objects in a scene than pixels.

Scanline rendering and rasterisation

Main article: Rasterisation

Rendering of the European Extremely Large Telescope.

A high-level representation of an image necessarily contains elements in a different domain from pixels. These elements are referred to as primitives. In a schematic drawing, for instance, line segments and curves might be primitives. In a graphical user interface, windows and buttons might be the primitives. In rendering of 3D models, triangles and polygons in space might be primitives.

If a pixel-by-pixel (image order) approach to rendering is impractical or too slow for some task, then a primitive-by-primitive (object order) approach to rendering may prove useful. Here, one loops through each of the primitives, determines which pixels in the image it affects, and modifies those pixels accordingly. This is called **rasterization**, and is the rendering method used by all current graphics cards.

Rasterization is frequently faster than pixel-by-pixel rendering. First, large areas of the image may be empty of primitives; rasterization will ignore these areas, but pixel-by-pixel rendering must pass through them. Second, rasterization can improve cache coherency and reduce redundant work by taking advantage of the fact that the pixels occupied by a single primitive tend to be contiguous in the image. For these reasons, rasterization is usually the approach of choice when interactive rendering is required; however, the pixel-by-pixel approach can often produce higher-quality images and is more versatile because it does not depend on as many assumptions about the image as rasterization.

The older form of rasterization is characterized by rendering an entire face (primitive) as a single color. Alternatively, rasterization can be done in a more complicated manner by first rendering the vertices of a face and then rendering the pixels of that face as a blending of the vertex colors. This version of rasterization has overtaken the old method as it allows the graphics to flow without complicated textures (a rasterized image when used face by face tends to have a very block-like effect if not covered in complex textures; the faces are not smooth because there is no gradual color change from one primitive to the next). This newer method of rasterization utilizes the graphics card's more taxing shading functions and still achieves better performance because the simpler textures stored in memory use less space. Sometimes designers will use one rasterization method on some faces and the other method on others based on the angle at which that face meets other joined faces, thus increasing speed and not hurting the overall effect.

Ray casting

In **ray casting** the geometry which has been modeled is parsed pixel by pixel, line by line, from the point of view outward, as if casting rays out from the point of view. Where an object is intersected, the color value at the point may be evaluated using several methods. In the simplest, the color value of the object at the point of intersection becomes the value of that pixel. The color may be determined from a texture-map. A more sophisticated method is to modify the colour value by an illumination factor, but without calculating the relationship to a simulated light source. To reduce artifacts, a number of rays in slightly different directions may be averaged.

Ray casting involves calculating the "view direction" (from camera position), and incrementally following along that "ray cast" through "solid 3d objects" in the scene, while accumulating the resulting value from each point in 3D space. This is related and similar to "ray tracing" except that the raycast is usually not "bounced" off surfaces (where the "ray tracing" indicates that it is tracing out the lights path including bounces). "Ray casting" implies that the light ray is following a straight path (which may include travelling through semi-transparent objects). The ray cast is a vector that can originate from the camera or from the scene endpoint ("back to front", or "front to back"). Sometimes the final light value is a derived from a "transfer function" and sometimes it's used directly.

Rough simulations of optical properties may be additionally employed: a simple calculation of the ray from the object to the point of view is made. Another calculation is made of the angle of incidence of light rays from the light source(s), and from these as well as the specified intensities of the light sources, the value of the pixel is calculated. Another simulation uses illumination plotted from a radiosity algorithm, or a combination of these two.

Ray tracing

Spiral Sphere and Julia, Detail, a computer-generated image created by visual artist Robert W. McGregor using only POV-Ray 3.6 and its built-in scene description language.

Main article: Ray tracing (graphics)

Ray tracing aims to simulate the natural flow of light, interpreted as particles. Often, ray tracing methods are utilized to approximate the solution to the rendering equation by applying Monte Carlo methods to it. Some of the most used methods are path tracing, bidirectional path tracing, or Metropolis light transport, but also semi realistic methods are in use, like Whitted Style Ray Tracing, or hybrids. While most implementations let light propagate on straight lines, applications exist to simulate relativistic spacetime effects.[1]

In a final, production quality rendering of a ray traced work, multiple rays are generally shot for each pixel, and traced not just to the first object of intersection, but rather, through a number of sequential 'bounces', using the known laws of optics such as "angle of incidence equals angle of reflection" and more advanced laws that deal with refraction and surface roughness.

Once the ray either encounters a light source, or more probably once a set limiting number of bounces has been evaluated, then the surface illumination at that final point is evaluated using techniques described above, and the changes along the way through the various bounces evaluated to estimate a value observed at the point of view. This is all repeated for each sample, for each pixel.

In distribution ray tracing, at each point of intersection, multiple rays may be spawned. In path tracing, however, only a single ray or none is fired at each intersection, utilizing the statistical nature of Monte Carlo experiments.

As a brute-force method, ray tracing has been too slow to consider for real-time, and until recently too slow even to consider for short films of any degree of quality, although it has been used for special effects sequences, and in advertising, where a short portion of high quality (perhaps even photorealistic) footage is required.

However, efforts at optimizing to reduce the number of calculations needed in portions of a work where detail is not high or does not depend on ray tracing features have led to a realistic possibility of wider use of ray tracing. There is now some hardware accelerated ray tracing equipment, at least in prototype phase, and some game demos which show use of real-time software or hardware ray tracing.

Radiosity

Main article: Radiosity (computer graphics)

Radiosity is a method which attempts to simulate the way in which directly illuminated surfaces act as indirect light sources that illuminate other surfaces. This produces more realistic shading and seems to better capture the 'ambience' of an indoor scene. A classic example is the way that shadows 'hug' the corners of rooms.

The optical basis of the simulation is that some diffused light from a given point on a given surface is reflected in a large spectrum of directions and illuminates the area around it.

The simulation technique may vary in complexity. Many renderings have a very rough estimate of radiosity, simply illuminating an entire scene very slightly with a factor known as ambiance. However, when advanced radiosity estimation is coupled with a high quality ray tracing algorithm, images may exhibit convincing realism, particularly for indoor scenes.

In advanced radiosity simulation, recursive, finite-element algorithms 'bounce' light back and forth between surfaces in the model, until some recursion limit is reached. The colouring of one surface in this way influences the colouring of a neighbouring surface, and vice versa. The resulting values of illumination throughout the model (sometimes including for empty spaces) are stored and used as additional inputs when performing calculations in a ray-casting or ray-tracing model.

Due to the iterative/recursive nature of the technique, complex objects are particularly slow to emulate. Prior to the standardization of rapid radiosity calculation, some digital artists used a technique referred to loosely as false radiosity by darkening areas of texture maps corresponding to corners, joints and recesses, and applying them via self-illumination or diffuse mapping for scanline rendering. Even now, advanced radiosity calculations may be reserved for calculating the ambiance of the room, from the light reflecting off walls, floor and ceiling, without examining the contribution that complex objects make to the radiosity—or complex objects may be replaced in the radiosity calculation with simpler objects of similar size and texture.

Radiosity calculations are viewpoint independent which increases the computations involved, but makes them useful for all viewpoints. If there is little rearrangement of radiosity objects in the scene, the same radiosity data may be reused for a number of frames, making radiosity an effective way to improve on the flatness of ray casting, without seriously impacting the overall rendering time-per-frame.

Because of this, radiosity is a prime component of leading real-time rendering methods, and has been used from beginning-to-end to create a large number of well-known recent feature-length animated 3D-cartoon films.

Sampling and filtering

One problem that any rendering system must deal with, no matter which approach it takes, is the **sampling problem**. Essentially, the rendering process tries to depict a continuous function from image space to colors by using a finite number of pixels. As a consequence of the Nyquist–Shannon sampling theorem (or Kotelnikov theorem), any spatial waveform that can be displayed must consist of at least two pixels, which is proportional to image resolution. In simpler terms, this expresses the idea that an image cannot display details, peaks or troughs in color or intensity, that are smaller than one pixel.

If a naive rendering algorithm is used without any filtering, high frequencies in the image function will cause ugly aliasing to be present in the final image. Aliasing typically manifests itself as jaggies, or jagged edges on objects where the pixel grid is visible. In order to remove aliasing, all rendering algorithms (if they are to produce good-looking images) must use some kind of low-pass filter on the image function to remove high frequencies, a process called antialiasing.

Optimization

Due to the large number of calculations, a work in progress is usually only rendered in detail appropriate to the portion of the work being developed at a given time, so in the initial stages of modeling, wireframe and ray casting may be used, even where the target output is ray tracing with radiosity. It is also common to render only parts of the scene at high detail, and to remove objects that are not important to what is currently being developed.

For real-time, it is appropriate to simplify one or more common approximations, and tune to the exact parameters of the scenery in question, which is also tuned to the agreed parameters to get the most 'bang for the buck'.

Academic core

Main article: Unbiased rendering

The implementation of a realistic renderer always has some basic element of physical simulation or emulation — some computation which resembles or abstracts a real physical process.

The term "*physically based*" indicates the use of physical models and approximations that are more general and widely accepted outside rendering. A particular set of related techniques have gradually become established in the rendering community.

The basic concepts are moderately straightforward, but intractable to calculate; and a single elegant algorithm or approach has been elusive for more general purpose renderers. In order to meet demands of robustness, accuracy and practicality, an implementation will be a complex combination of different techniques.

Rendering research is concerned with both the adaptation of scientific models and their efficient application.

The rendering equation

Main article: Rendering equation

This is the key academic/theoretical concept in rendering. It serves as the most abstract formal expression of the non-perceptual aspect of rendering. All more complete algorithms can be seen as solutions to particular formulations of this equation.

Meaning: at a particular position and direction, the outgoing light (L_o) is the sum of the emitted light (L_e) and the reflected light. The reflected light being the sum of the incoming light (L_i) from all directions, multiplied by the surface reflection and incoming angle. By connecting outward light to inward light, via an interaction point, this equation stands for the whole 'light transport' — all the movement of light — in a scene.

The bidirectional reflectance distribution function

The **bidirectional reflectance distribution function** (BRDF) expresses a simple model of light interaction with a surface as follows:

Light interaction is often approximated by the even simpler models: diffuse reflection and specular reflection, although both can ALSO be BRDFs.

Geometric optics

Rendering is practically exclusively concerned with the particle aspect of light physics — known as geometrical optics. Treating light, at its basic level, as particles bouncing around is a simplification, but appropriate: the wave aspects of light are negligible in most scenes, and are significantly more difficult to simulate. Notable wave aspect phenomena include diffraction (as seen in the colours of CDs and DVDs) and polarisation (as seen in LCDs). Both types of effect, if needed, are made by appearance-oriented adjustment of the reflection model.

Visual perception

Though it receives less attention, an understanding of human visual perception is valuable to rendering. This is mainly because image displays and human perception have restricted ranges. A renderer can simulate an almost infinite range of light brightness and color, but current displays — movie screen, computer monitor, etc. — cannot handle so much, and something must be discarded or compressed. Human perception also has limits, and so does not need to be given large-range images to create realism. This can help solve the problem of fitting images into displays, and, furthermore, suggest what short-cuts could be used in the rendering simulation, since certain subtleties won't be noticeable. This related subject is tone mapping.

Mathematics used in rendering includes: linear algebra, calculus, numerical mathematics, signal processing, and Monte Carlo methods.

Rendering for movies often takes place on a network of tightly connected computers known as a render farm.

The current[when?] state of the art in 3-D image description for movie creation is the mental ray scene description language designed at mental images and RenderMan Shading Language designed at Pixar.[2] (compare with simpler 3D fileformats such as VRML or APIs such as OpenGL and DirectX tailored for 3D hardware accelerators).

Other renderers (including proprietary ones) can and are sometimes used, but most other renderers tend to miss one or more of the often needed features like good texture filtering, texture caching, programmable shaders, highend geometry types like hair, subdivision or nurbs surfaces with tesselation on demand, geometry caching, raytracing with geometry caching, high quality shadow mapping, speed or patent-free implementations. Other highly sought features these days may include interactive photorealistic rendering (IPR) and hardware rendering/shading.

Some renderers execute on the GPU instead of the CPU (eg. FurryBall, Redshift, Octane). The parallelized nature of GPUs can be used for shorter render times. However, GPU renderers are constrained by the amount of video memory available.

Chronology of important published ideas

References

Sr.No	Title	Author	Publisher	Edition	Year of Edition
1	Cinematogrphy	David Mullen	-	-	-
2	Cinematogrphy Motion Picture Filming Techniqes	Kindle Edition	-	-	-
3	Cinematogrphy Theory & Practice	Blain Brown	-	-	-
4	Spealling of Films	Satyajit Ray	-	-	-
5	Filmmaker Handbook	Steven Ascher	-	-	
6	Read a Film	James Monoco	-	-	-

PAPER : VII 3D Rigging (Animation) 50 hrs.

Course Type: Theory / Practical	Theory
Required/Elective	Required
Prerequisite	2D animation & 3D animation
Teaching Scheme (Lecture/Practical/Tutorial/Drawing)	02/02/00/00 Hours
Total contact Hours (Lecture/Practical/Tutorial/Drawing)	50/00/00/00 Hours
EvaluationScheme: Theory Theory Paper /Term Work/Oral/Practical	--/--/--/--

Course Outcomes (COs):

Course Outcomes(COs): Upon completion of this course, students will be able to		Mapping with PO's
CO107.1	Students will create a demo-reel of appropriate artwork based on the research produced in the class.	4,9
CO107.2	Ability to create simple Mel scripts using expressions, to automatize controls on the rig	4,7
CO107.3	Ability to plan and design IK solutions for various types of structures based on the needs of animation.	5,7
CO107.4	Demonstrate ability to evaluate a mesh, and design appropriate rigging techniques to make it animatable.	5
CO107.5	Demonstrate ability to skin and paint weights on organic deformable meshes, and hard non-deformable meshees	2,9
CO107.6	The ability to design control systems that are user friendly, and intuitive to the end user, the animator	1,2,7

Correlation matrix of Course outcomes with Programmed outcomes (CO-PO)
1=Low correlation, 2=Medium correlation, 3=High correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2
CO107.1	-	-	-	3	-	-	-	-	2	-	2
CO107.2	-	-	-	3	1	-	2	-	-	-	2
CO107.3	-	-	-	-	3	-	2	-	-	-	2
CO107.4	-	-	-	-	3	-	-	-	-	-	2
CO107.5	-	2	-	-	-	-	-	-		-	2
CO107.6	1	2	-	-	-	-	-	-	3	1	2

Skelett (Rig) eines 3D-Modells

Das **Rigging** ist eine Arbeitstechnik im Bereich der 3D-Animation.

Beim Rigging wird mithilfe einer entsprechenden Software ein sogenanntes *Skelett* bzw. *Rig* aus Bones (Knochen) oder auch Joints (Gelenken) konstruiert, das festlegt, wie die einzelnen Teile eines *Meshes* (eines Polygonnetzes) bewegt werden können. Nicht selten orientiert man sich bei der Konstruktion an der Beschaffenheit eines tatsächlichen Skelettes, beispielsweise bildet man etwa einen echten Oberschenkelknochen oder ein echtes Kniegelenk nach.

Nachdem das Skelett bzw. Rig erstellt wurde, kann es mit dem Polygonnetz gekoppelt werden, in einem weiteren Arbeitsschritt, dem sogenannten Skinning, sind oft noch einige kleinere Fehler auszubügeln, die beim Koppeln des Meshes an das Rig aufgetreten sind.

Rigging-fähige 3D-Grafiksoftware (Auswahl)

- Softimage XSI
- Animation:Master
- Maya
- 3D Studio Max
- Cinema 4D
- Anim8or
- Blender
- Lightwave 3D
- Luxology Modo
- SideFX Houdini

Literatur

- Eyal Assaf: Rigging for Games: A Primer for Technical Artists Using Maya and Python, CRC Press, 2015, ISBN 9781317802945
- Tina O'Hailey: Rig it Right!: Maya Animation Rigging Concepts, Taylor & Francis, 2013, ISBN 9780240820798
- Andy Beane: 3D Animation Essentials, John Wiley & Sons, 2012, ISBN 9781118239056

- Jonny Gorden: LightWave 3D 8 Cartoon Character Creation: Rigging and Animation, Jones & Bartlett Publishers, 2004, ISBN 9781556222542
- Character Rigging and Animation: A Hands-on Introduction to the Key Tools and Techniques of Character Rigging and Animation with Maya, Alias, 2004
- Binh Huy Le: Example-based Rigging and Real-time Animation of Characters with Linear Skinning Models, University of Houston, 2014

Sr.No	Title	Author	Publisher	Edition	Year of Edition
1	Fast animation & Rigging	Bhaumik Patel	-	-	-
2	Rigging Video Game	Alex Zaragoza	-	-	-
3	3D Animation & VFX	Stwart Jones	-	-	-
4	Maya TMS	Alias Ware Front	-	-	-
5	How to Cheat in Maya	Eric Luhta	-	-	-
6	Blender	Oliver Villar	-	-	-

A) Practical **50Hrs.**

1. Story board 2. Animation Principals 3. Advance Photoshop

4. Flash

B) Practical **100Hrs.**

1. Maya 3D modeling

C) Project Work **50 Hrs.**

1. Photoshop/ Flash work
2.3D Modeling Demo Reel