



## Course Overview

### Multimedia Techniques & Applications

Yu-Ting Wu

1

## Course Information

- **Meeting time:** 09:10 - 12:00, Monday
- **Classroom:** 資B1F-04
- **Instructor:** 吳昱霆 ([Yu-Ting Wu](#))
- **Teaching assistants:** TBA
- **Course webpage:**
  - <https://kevincosner.github.io/courses/MMTA2022/>
- **Grading:**
  - Assignments: 35%
  - Report: 20%
  - Final Project: 40%
  - Participation: 5%

2

2

## References

- **No specific textbook for this course**
  - We will use information from books, journals, and proceedings
  - If you still want some textbooks ...



- Some of the materials are borrowed from the course "*Digital Visual Effects*", by Prof. Yung-Yu Chuang, National Taiwan University

3

3

## Copyright Statement

- We will use lots of materials from feature movies, games, capture or display devices, the copyrights belong to the producers and developers of the original content or devices

4

4

1

## What is Multimedia ?

5

5

## Multi --- Media

6

6

## What is Media ?

7

7

## Media

- The plural of medium
  - Communication channels for delivering information



newspaper



magazine



outdoor advertising



radio



TV programs



internet

8

8

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## Media

- Example: *it was a dark and stormy night*

novel

comic

video

radio

drama

9

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## Basic Components of Media

text

graphics

graphics

sound

video, animation

video, animation

- We will introduce these components in the following courses

10

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## Digital Media

- In this course, we focus on **digital media**, which can be represented **digitally**
  - Structured as collections of bits
  - Manipulated by programs
  - Stored on disks and other storage devices
  - Transmitted over networks

11

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## Recap: Digital Representation

- Computers are built out of devices that can only be in one of two states (well defined voltages)
- We usually say these devices store and operate in **bits**

0V, off, false, 0


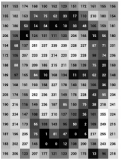
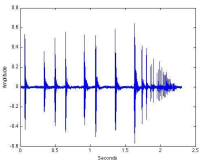
3.5V, on, true, 1

12

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## Recap: Digital Representation (cont.)

- Using the representation of 0/1, we can interpret the group of bits (bytes or words) into a number to base 2
  - Ex: 01100001 → 97
- We can then express data using bits, bytes, or words

- We can also build electronic devices to perform the basic arithmetic operations
  - Addition, subtraction, multiplication, division, ...

13

13

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## Recap: Digital Representation (cont.)

- We can also build mapping
  - ASCII code
  - Instruction set
  - ...

		Target <tar>	
		4R or Mx	12R
INC	S0	-- C Z N	-- Z <sup>2</sup> N <sup>2</sup>
DEC	S1	-- C Z N	-- Z <sup>2</sup> N <sup>2</sup>
ADDC	S2	O C Z N	-- -- --
SUBB	S3	O C Z N	-- -- --
ROL	S4	-- C <sup>2</sup> Z N	-- -- --
RORC	S5	-- C <sup>2</sup> Z N	-- -- --
AND	S6	-- -- Z N	-- -- --
OR	S7	-- -- Z N	-- Z <sup>2</sup> N <sup>2</sup>
XOR	S8	-- -- Z N	-- -- --
CMP	S9	-- C <sup>2</sup> Z <sup>2</sup>	-- -- --
PUSH	SA	-- -- --	-- -- --
POP	SB	-- -- Z <sup>2</sup> N <sup>2</sup>	-- -- --
JMP	SC	-- -- --	-- -- --
JBR	SD	-- -- --	-- -- --
NOP	SE	-- -- --	-- -- --
MOV	SF	-- -- Z <sup>2</sup> N <sup>2</sup>	-- -- Z <sup>2</sup> N <sup>2</sup>

Decimal	Hex Char	Decimal	Hex Char	Decimal	Hex Char	Decimal	Hex Char
0	0	16	P </td <td>32</td> <td>@</td> <td>48</td> <td>H</td>	32	@	48	H
1	1	17	Q	33	A	49	I
2	2	18	R	34	B	50	J
3	3	19	S	35	C	51	K
4	4	20	T	36	D	52	L
5	5	21	U	37	E	53	M
6	6	22	V	38	F	54	N
7	7	23	W	39	G	55	O
8	8	24	X	40	H	56	P
9	9	25	Y	41	I	57	Q
10	A	26	Z	42	J	58	R
11	B	27	[	43	K	59	S
12	C	28	\	44	L	60	T
13	D	29	]	45	M	61	U
14	E	30	^	46	N	62	V
15	F	31	_	47	O	63	W
16	G	32	`	48	P	64	X
17	H	33	{	49	Q	65	Y
18	I	34		50	R	66	Z
19	J	35	}	51	S	67	[
20	K	36	~	52	T	68	\
21	L	37		53	U	69	]
22	M	38		54	V	70	^
23	N	39		55	W	71	_
24	O	40		56	X	72	
25	P	41		57	Y	73	
26	Q	42		58	Z	74	
27	R	43		59	[	75	
28	S	44		60	\	76	
29	T	45		61	]	77	
30	U	46		62	^	78	
31	V	47		63	_	79	
32	W	48		64		80	
33	X	49		65		81	
34	Y	50		66		82	
35	Z	51		67		83	
36	[	52		68		84	
37	\	53		69		85	
38	]	54		70		86	
39	^	55		71		87	
40	_	56		72		88	
41		57		73		89	
42		58		74		90	
43		59		75		91	
44		60		76		92	
45		61		77		93	
46		62		78		94	
47		63		79		95	
48		64		80		96	
49		65		81		97	
50		66		82		98	
51		67		83		99	
52		68		84		100	
53		69		85		101	
54		70		86		102	
55		71		87		103	
56		72		88		104	
57		73		89		105	
58		74		90		106	
59		75		91		107	
60		76		92		108	
61		77		93		109	
62		78		94		110	
63		79		95		111	
64		80		96		112	
65		81		97		113	
66		82		98		114	
67		83		99		115	
68		84		100		116	
69		85		101		117	
70		86		102		118	
71		87		103		119	
72		88		104		120	
73		89		105		121	
74		90		106		122	
75		91		107		123	
76		92		108		124	
77		93		109		125	
78		94		110		126	
79		95		111		127	
80		96		112		128	
81		97		113		129	
82		98		114		130	
83		99		115		131	
84		100		116		132	
85		101		117		133	
86		102		118		134	
87		103		119		135	
88		104		120		136	
89		105		121		137	
90		106		122		138	
91		107		123		139	
92		108		124		140	
93		109		125		141	
94		110		126		142	
95		111		127		143	
96		112		128		144	
97		113		129		145	
98		114		130		146	
99		115		131		147	
100		116		132		148	
101		117		133		149	
102		118		134		150	
103		119		135		151	
104		120		136		152	
105		121		137		153	
106		122		138		154	
107		123		139		155	
108		124		140		156	
109		125		141		157	
110		126		142		158	
111		127		143		159	
112		128		144		160	
113		129		145		161	
114		130		146		162	
115		131		147		163	
116		132		148		164	
117		133		149		165	
118		134		150		166	
119		135		151		167	
120		136		152		168	
121		137		153		169	
122		138		154		170	
123		139		155		171	
124		140		156		172	
125		141		157		173	
126		142		158		174	
127		143		159		175	
128		144		160		176	
129		145		161		177	
130		146		162		178	
131		147		163		179	
132		148		164		180	
133		149		165		181	
134		150		166		182	
135		151		167		183	
136		152		168		184	
137		153		169		185	
138		154		170		186	
139		155		171		187	
140		156		172		188	
141		157		173		189	
142		158		174		190	
143		159		175		191	
144		160		176		192	
145		161		177		193	
146		162		178		194	
147		163		179		195	
148		164		180		196	
149		165		181		197	
150		166		182		198	
151		167		183		199	
152		168		184		200	
153		169		185		201	
154		170		186		202	
155		171		187		203	
156		172		188		204	
157		173		189		205	
158		174		190		206	
159		175		191		207	
160		176		192		208	
161		177		193		209	
162		178		194		210	
163		179		195		211	
164		180		196		212	
165		181		197		213	
166		182		198		214	
167		183		199		215	
168		184		200		216	
169		185		201		217	
170		186		202		218	
171		187		203		219	
172		188		204		220	
173		189		205		221	
174		190		206		222	
175		191		207		223	
176		192		208		224	
177		193		209		225	
178		194		210		226	
179		195		211		227	
180		196		212		228	
181		197		213		229	
182		198		214		230	
183		199		215		231	
184		200		216		232	
185		201		217		233	
186		202					

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### Recap: Digitalization (cont.)

- Quality of digitalization
  - How closely the original signal can be reconstructed
  - Depends on
    - Reconstruction algorithms
    - Quality of the sampled data

analog signal    sampled data    reconstructed signal using "sample and hold"    under sampling

17

17

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### Recap: Digitalization (cont.)

- Aliasing
  - staircase pattern or jaggies
  - Moire pattern ( $x^2+y^2$ )
  - Wagon Wheel effect
  - change of sound pitch

18

18

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### Recap: Frequency Domain

- Most functions can be decomposed into a weighted sum of shifted sinusoids
- Each function (signal) has two representations
  - Ex: image
    - Spatial domain: normal representation
    - Frequency domain: spectral representation
  - The **Fourier transform** converts between the two representations

$$\begin{aligned}
 \text{Spatial Domain } f(x) &\Rightarrow F(\omega) = \int_{-\infty}^{\infty} f(x)e^{-i\omega x} dx \Rightarrow \text{Frequency Domain } F(\omega) \\
 \text{Frequency Domain } F(\omega) &\Leftarrow f(x) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega)e^{i\omega x} d\omega \Leftarrow \text{Spatial Domain } f(x)
 \end{aligned}$$

19

19

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### Recap: Sampling Theorem

- Claude Shannon [1949]
  - "A signal can be reconstructed from its samples without loss of information if the original signal has no frequencies above  $\frac{1}{2}$  the sampling frequency"
  - Nyquist frequency

20

20

## Digital Media

- In this course, we focus on **digital media**, which can be represented **digitally**
  - Structured as collections of bits
  - Manipulated by programs
  - Stored on disks and other storage devices
  - Transmitted over networks



- The shared digital representation means that **different media can be combined into Multimedia**

21

21

## Combination of Different Media

- The integration of media is natural
  - We perceive the world through all the senses we have at once
- The idea is not new



AL JOLSON "The Jazz Singer" in 1927

22

22

## Multimedia

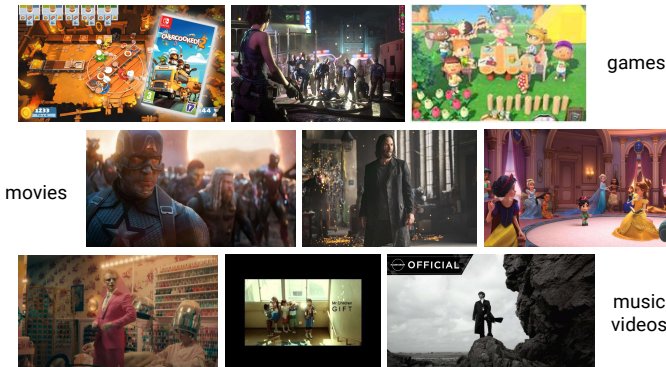
- Multimedia is considered slightly different from multiple media or combined media
  - Multiple media or combined media require users to switch between modalities
  - True multimedia requires us to combine modalities at the same time
    - Can bring in new content, such as the pop music videos
    - Usually provide some interactivity
- In this course, we also focus on **digital multimedia**, which can represent text, sound, and pictures using **bits**
  - Control the order of each media component
  - Response to input from a user, thus being **interactive!**

23

23

## Applications of Digital Multimedia

- Entertainment



24

24

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## Applications of Digital Multimedia

- Entertainment
  - The production can make extremely different experiences

1993



Myst

2021



1997



2020



Final Fantasy VII


25

25

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## Applications of Digital Multimedia

- Entertainment
  - The production can make extremely different experiences



Avengers  
(1978)

26

26

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## Applications of Digital Multimedia

- Entertainment
  - The production can make extremely different experiences



Avengers: Infinite War  
(2018)

27

27

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## Applications of Digital Multimedia

- Education
  - film clips and original recordings
  - virtual experiments or surgery
  - teaching materials





















28

28

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## Applications of Digital Multimedia

- Instruction or Training

29

29

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## Applications of Digital Multimedia

- Presentation and promotions

30

30

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## Applications of Digital Multimedia

- Visualization

Character	Follower Count
Lamperouge, Lelouch	101,499
Lawliet, L	82,618
Monkey D., Luffy	67,516
Elic, Edward	62,141
Yagami, Light	60,449
Levi	58,273
Okabe, Rintarou	58,226
Roronoa, Zoro	54,215
Uzumaki, Naruto	50,240
Sakata, Gintoki	46,186

OCT 2019

from [https://www.youtube.com/watch?v=\\_CvtsaFgpFA](https://www.youtube.com/watch?v=_CvtsaFgpFA)

31

31

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## Applications of Digital Multimedia

- Forensic

32

32



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## Delivery of Digital Multimedia

- Get the material from its producer to its consumers
- Types of delivery
  - Offline
    - CD, VCD, DVD, BD, floppy disks, USB sticks ...
  - Online
    - Internet
  - Hybrid

33

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## Delivery of Digital Multimedia

- Offline delivery: removable storage medium
  - Still widely used in areas with low bandwidth to the internet

Capacity	Medium	Year Introduced	Encoding
~150 KB	8-inch floppy disk	since 1969	
~1.2 MB	5.25-inch floppy disk	since 1976	
~2.88 MB	3.5-inch floppy disk	since 1984	
650 MB	CD-ROM [Compact Disc Read-Only Memory]	since 1982	
800 MB	VCD [Video Compact Disc]	since 1993	MPEG-1
4.7 ~ 17 GB	DVD [Digital Versatile Disc]	since 1995	MPEG-2
25 ~ 128 GB	BD [Blu-ray Disc]	since 2006	MPEG-4 (H.264)

34

33

34

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## Delivery of Digital Multimedia

- The success of CD-ROM (and the following VCD, DVD) brings the surge in interest in multimedia

35

35

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## Delivery of Digital Multimedia

- Online delivery: network
  - Client – Server (most common)
  - Peer – to – Peer

```

graph LR
    Client1[Client] --- Internet((Internet))
    Client2[Client] --- Internet
    Server[Server] --- Internet
    Internet --- Server
    subgraph Storage
    Server
    end
    Storage --- Holder[holder of the data (centralized storage)]
  
```

- Online delivery offers opportunities which are not available offline
  - Video conferencing
  - Broadcast

36

36

## Delivery of Digital Multimedia

- Hybrid (of offline & online) delivery
  - Physical removable medium (main content) + online update / or downloadable content (DLC)



37

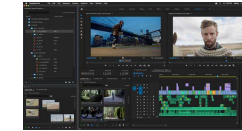
37

## Production of Digital Multimedia

- The making of multimedia requires authoring systems
- Preparation of individual media elements
  - Integration into a finished production



Adobe Photoshop



Adobe Premiere



Blender



Unity / Unreal Engine

38

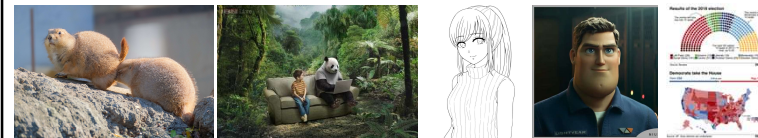
38

## Topics We Plan to Cover

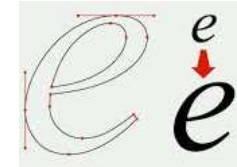
39

39

## Graphics



vector graphics



bitmapped graphics



40

40

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## Color

RGB  
CMYK

PANTONE  
CMYK newsprint  
CMYK coated  
RGB  
Visible

6583  
LEVEL 3  
LINES 39

2240 SCORE 1445  
1 LINES 2  
7 LEVEL 4  
GOMER

41

41

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## Bitmapped Images

Zoom, 40 x 40

600 x 336

42

42

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## Camera

Nikon

Note we are not teaching

普通拍法

男友必學拍照技巧！  
手機就能拍高質感相片

43

43

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## High Dynamic Imaging

BEFORE

AFTER

44

44

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## Panorama

45

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## Vector Graphics

46

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## 3D Graphics

47

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## 3D Graphics


- Create the virtual 3D world description
- Create a 2D picture from the virtual 3D world description

48

## Text and Font

### ASCII TABLE

Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char
0	0		32	20	SPACE	64	40	@	96	60	W
1	1		33	21	!	65	41	A	97	61	w
2	2		34	22	"	66	42	B	98	62	W
3	3		35	23	#	67	43	C	99	63	w
4	4		36	24	\$	68	44	D	100	64	x
5	5		37	25	%	69	45	E	101	65	X
6	6		38	26	&	70	46	F	102	66	f
7	7		39	27	'	71	47	G	103	67	f
8	8		40	28	(	72	48	H	104	68	h
9	9		41	29	)	73	49	I	105	69	i
10	A		42	2A	*	74	4A	J	106	6A	j
11	B		43	2B	+	75	4B	K	107	6B	k
12	C		44	2C	,	76	4C	L	108	6C	l
13	D		45	2D	-	77	4D	M	109	6D	m
14	E		46	2E	.	78	4E	N	110	6E	n
15	F		47	2F	/	79	4F	O	111	6F	o
16	10		48	30	0	80	50	P	112	70	p
17	11		49	31	1	81	51	Q	113	71	q
18	12		50	32	2	82	52	R	114	72	r
19	13		51	33	3	83	53	S	115	73	s
20	14		52	34	4	84	54	T	116	74	t
21	15		53	35	5	85	55	U	117	75	u
22	16		54	36	6	86	56	V	118	76	v
23	17		55	37	7	87	57	W	119	77	w
24	18		56	38	8	88	58	X	120	78	x
25	19		57	39	9	89	59	Y	121	79	y
26	1A		58	3A	:	90	5A	Z	122	7A	z
27	1B		59	3B	;	91	5B	[	123	7B	{
28	1C		60	3C	<	92	5C	\	124	7C	
29	1D		61	3D	=	93	5D	]	125	7D	~
30	1E		62	3E	>	94	5E	^	126	7E	^
31	1F		63	3F	?	95	5F	_	127	7F	_




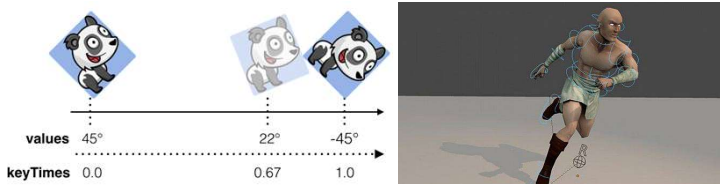
Lucida Bright goes well with *Lucida Bright italic*, and *bold italic*, but not nearly so well with Palatino.

**A Display Font:  
Bodoni Highlight**

**Display fonts are designed for short pieces of text, such as headlines. They are not intended for use in lengthy passages.**

49

## Video and Animation






values 45° 22° -45°

keyTimes 0.0 0.67 1.0


50

## Sound

51

## Game Production



- Planning**
  - What are we building?
  - What is our budget?
  - Who is the audience?
  - Which platform will it be on?
- Pre-production**
  - Storyboarding, storytelling.
  - Technological capabilities.
  - Early prototyping.
  - Milestone scheduling.
- Production**
  - Modeling, designing.
  - Audio, visual effects.
  - Physics, mechanics.
  - Developing, rendering.
- Testing**
  - Bug identifying.
  - Feature exploitation.
  - Is the game too easy/hard?
  - Is the game even fun?
- Pre-launch**
  - Alpha/Beta releases.
  - Marketing hype.
  - Gaming conventions.
  - Independent advertising.
- Launch**
  - Major bug squashing.
  - Minor bug squashing.
  - Polishing.
  - Master release.
- Post-production**
  - More bug squashing.
  - Game patching.
  - Game balancing.
  - New content development.

by Devin Pickell, G2

52

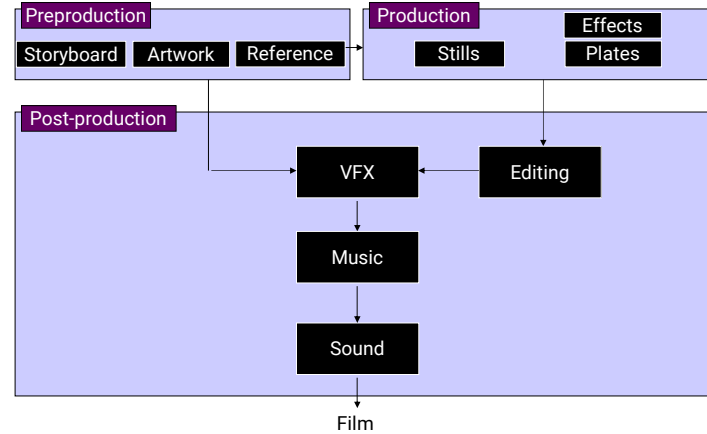
### Game Engines



53

53

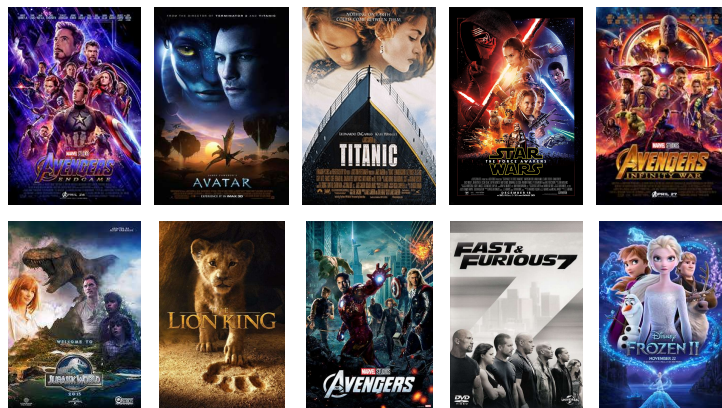
### Film Production Pipeline



54

54

### VFX: Top Selling Movies



55

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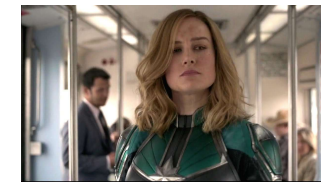
### VFX: Image Morphing



Michael Jackson:  
Black or White  
(1991)



X-Men: Dark Phoenix (2019)



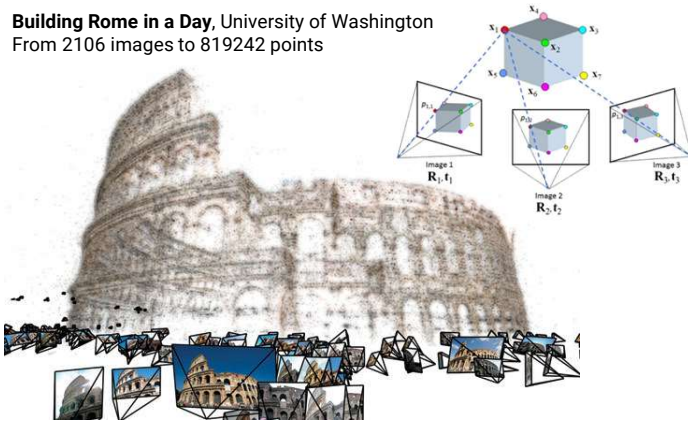
Captain Marvel (2019)

56

56

## VFX: Match Move

Building Rome in a Day, University of Washington  
From 2106 images to 819242 points



57

57

## VFX: Match Move



Jurassic Park  
(1993)

58

58

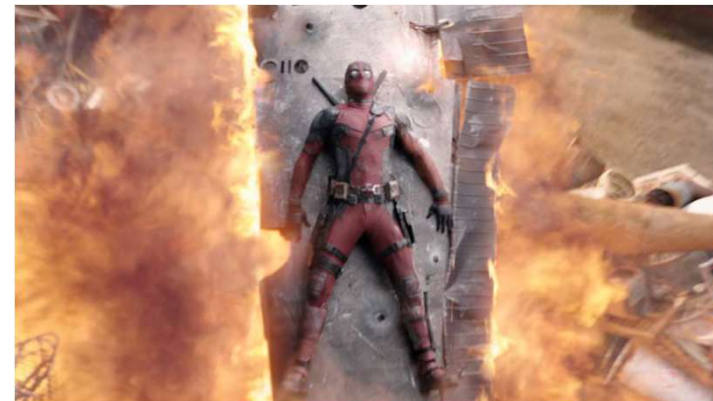
## VFX: Matting & Compositing



59

59

## VFX: Matting & Compositing



60

60

## VFX: Matting & Compositing



61

61

## VFX: Matting & Compositing



Clip: Z025\_R004\_D414S1 SRC TC: 16.0 卡提諾論壇 CK101.COM

要把身材高大的甘道夫和小矮人們拍攝在一起，我們是沒法在同一個片場的。和我一起拍攝的只有柱子上貼著的13張他們的照片，後面還有一個小燈，哪個角色說話了燈就亮起來。想像一下你在拍一場和13個人一起演的戲，但你卻只有獨自一人。這真的會把你的演技推到極限。我哭了，真的，我當時真的哭了。然後我還說出了聲：我認真演了一輩子不是為了跟這些照片對戲啊！

62

62

## Virtual Studio



63

63

## Virtual Reality



64

64



## Mixed Reality

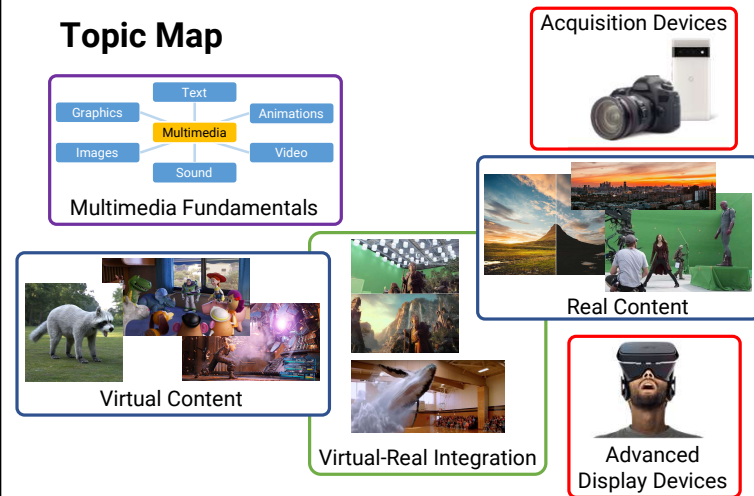


a promotional video by Magic Leap (2016)

65

65

## Topic Map



66

66

## Final Project

67

67

## Final Project

- Group work (3 students)
- A short film that contains some techniques taught in this course
  - Image and video editing
  - 3D virtual objects manipulation
  - Matchmove
  - Matting and compositing
  - Text
  - Sound


68

68

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### Examples: 405 the Movie

- Created solely by two visual effects artists in the year of 2000
- Took over three months of nights, weekends and any spare moments that they could find
- [https://en.wikipedia.org/wiki/405\\_\(film\)](https://en.wikipedia.org/wiki/405_(film))



69

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### Examples: 405 the Movie (cont.)

- Step 0: script and shooting plan

Shot#	Description	Full CG	CG	Length Frames
01	Title Animation	X	X	401
02	Freeway speeds beneath car			123
03	Speed Limit 65			120
04	LA Freeway from Overpass			238
05	Empty Freeway-Car enters frame	X	X	150
06	Pan From Freeway J looks at lack of traffic			237
07	Plane swings into landing position toward freeway	X	X	139
08	Hand on Gear shift			36
09	Plane lowers into view through rear window		X	84
10	Plane nears Car	X	X	66
11	J looks to side mirror-plane visible behind		X	84
12	Plane in sideview mirror		X	66
13	J looks from side view to rear view mirror - plane behind		X	27
14	J eyes react in rear view mirror-remove traffic		X	33
15	Plane chases Car toward camera	X	X	77

70


69

70

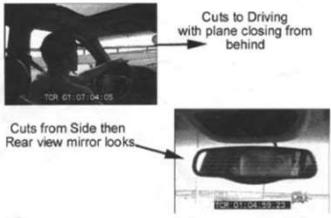
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### Examples: 405 the Movie (cont.)

- Step 1: shooting
  - Two days with a Canon Optura DV camera with progressive mode
  - 70 minutes raw footage



initial editing and pickup shots



Cuts to Driving with plane closing from behind


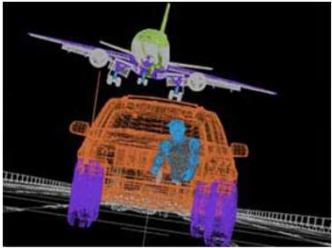

Cuts from Side then Rear view mirror looks

71

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### Examples: 405 the Movie (cont.)

- Step 2: building CG
  - Some shots are combined with VFX techniques

72

71

72

## Examples: 405 the Movie (cont.)

- Step 3: compositing
  - Shots with vehicle standing still in a backyard



73

73

## Examples: 405 the Movie (cont.)

- Step 4: fine touchup and music



74

74