

# PART III: Interaction Styles

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## Direct Manipulation & Immersive Environments

SEEM3510 Human-Computer Interaction

By Prof. Helen MENG & Prof. Philip FU

# Course Outline

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Part 1: Basics	Week 1 - Usability of Interactive Systems Week 2 - Universal Usability Week 3 - Guidelines, Principle and Theories	By Helen
Part 2: Development Process	Week 4 - Design Process (Assignment 2) Week 5 - Evaluation (Assignment 3)	By Philip
Part 3: Interaction Paradigms	Week 6 - Direct Manipulation & Immersive Environments	By Philip
	Week 7 Midterm Review and Exam (weeks 1-6 material)	By Philip
	Week 8 - Fluid Navigation: Menu and Form Fill-in	By Philip
	Week 9 Expressive Human and Command Languages	By Helen
Part 4: Additional Topics	Week 10 Interaction Devices Week 11 Communication and Collaboration	By Philip
	Week 12 Timely User Experience Week 13 Information Search and Data Visualization	By Helen

# “Direct Manipulation”

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- Goal
  - Introduce the concept of direct manipulation
  - History on direct manipulation
  - Examples of common uses
  - Discuss Multitouch, Virtual Reality and Augmented Reality
- Overview of topics in this module
  - Introduction: interaction styles
  - What is Direct Manipulation (DM)?
  - Examples of DM
  - Multitouch interactions
  - Virtual and Augmented Reality (VR & AR)
  - When AI meets VR & AR

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## Topics:

- Introduction: interaction styles
- What is Direct Manipulation (DM)?
- Examples of DM
- Multitouch interactions
- Virtual and Augmented Reality (VR & AR)
- When AI meets VR & AR

# Introduction

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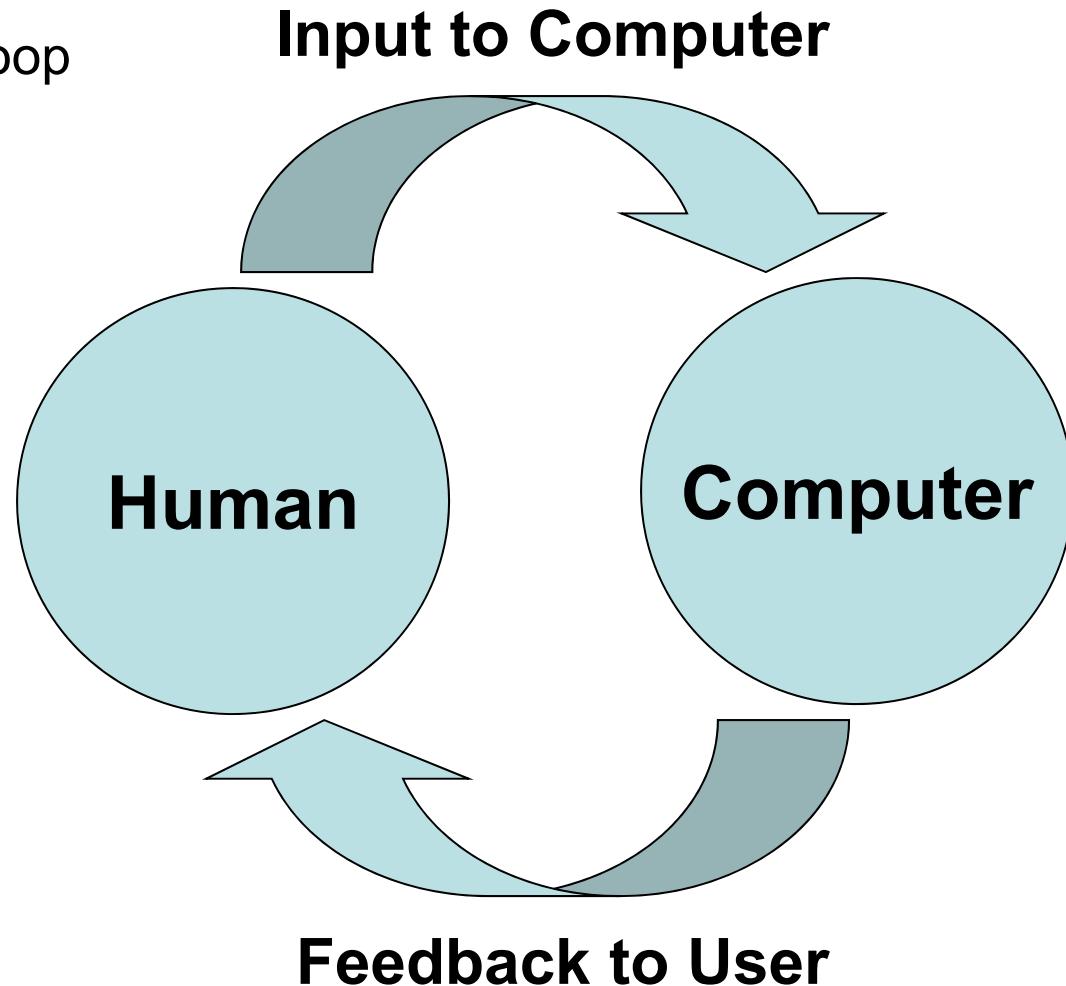
- The following are “**positive** feelings” associated with **good** user interfaces:
  - Mastery of the interface
  - Competence (adequacy) in performing tasks
  - Ease in learning the system originally and in assimilating advanced features
  - Confidence in the capacity to retain mastery over time
  - Eagerness to show the system off to novices
  - Desire to explore more powerful aspects of the system
  - *Enjoyment in using the system*

In the end, you feel **full control** as if the “**UI disappears**”

# Human-Computer Interaction

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Note: human-in-the-loop computing



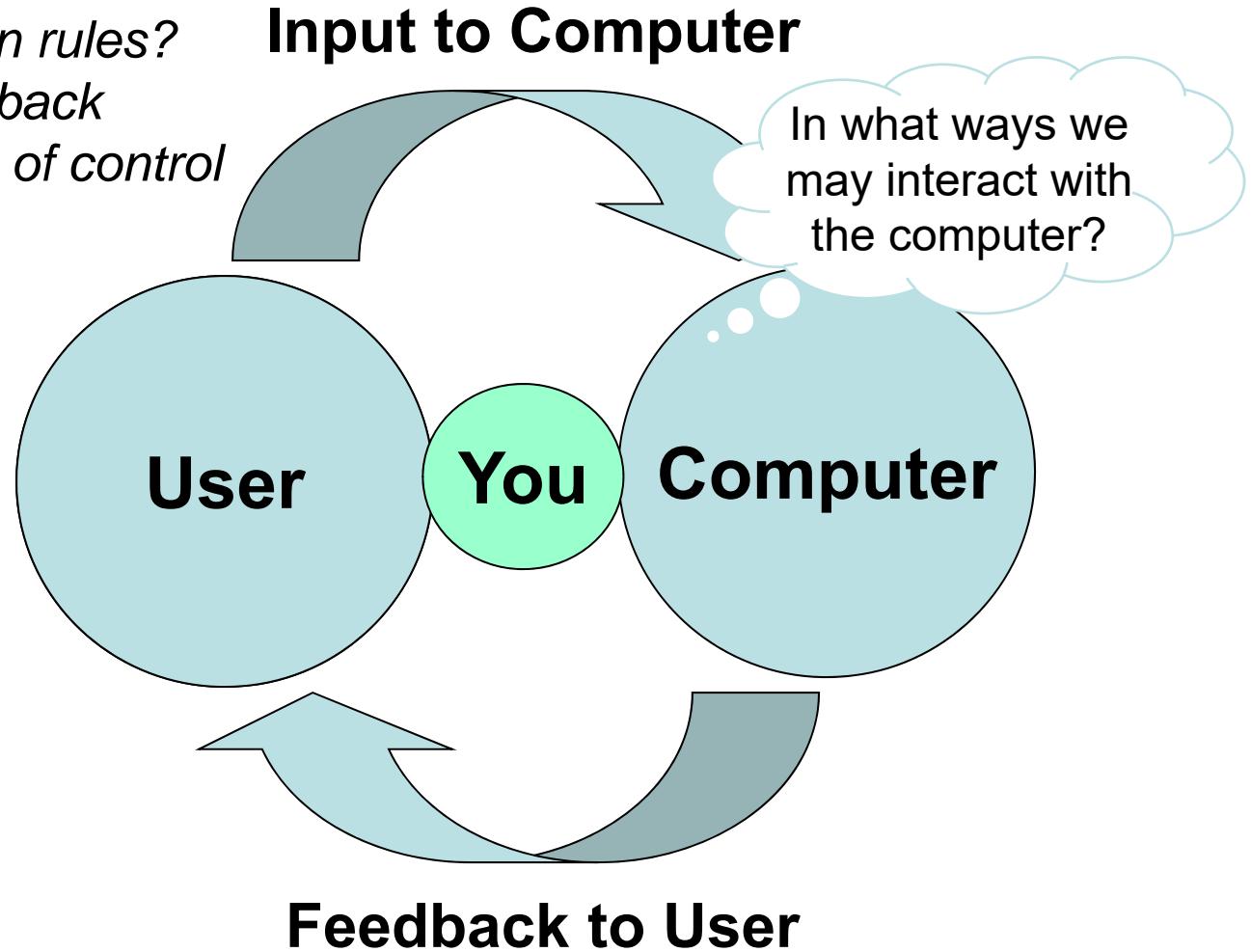
Think about when you use your phone, your computer, etc.

# Human-Computer Interaction

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*Remember which Golden rules?*

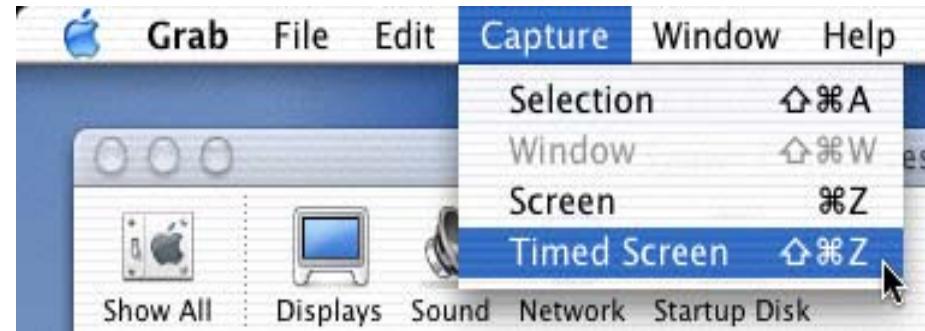
- Offer informative feedback
- Support internal locus of control



# Let's see a simple example, say delete a file!!!



1. Direct Manipulation



2. Menu Selection

Required •

Email Address •

Confirm Email Address •

Enter a Shipping Address

Address Nickname •  
For example, Home or Work. A nickname will help you locate this address quickly

First Name •  Last Name •

Care of / Company Name

Address Line 1 •

This is a P.O. Box or Military Address (APO or FPO)

3. Form filling

C:\WINNT\System32\cmd.exe

```
Usage: bddosc.exe path[s] [parameters]
Parameters:
/f, /files          scan files *           /R, /nor
/r, /arc            scan archives          /p, /prom
/i, /mail           scan mail databases   /O, /info
/d, /dis            disinfect files       /W, /nowai
/h, /noheuristics  no heuristics         /U, /vlist
/G, /log[=file]     create log file      /infext=e
/l, /list           log all files        /l, /del
/a, /all            scan all files       /ren
/e, /app             append to log file  /?, /help
/T, /tmp=path       set temporary path  * = defau
/k, /nopack          don't scan packed programs
/F, /inf=path       set infected quarantine folder
/E, /ext=ext1;ext2; scan only this extensions
/X, /xcl=ext1;ext2; exclude from scan this extension
/U, /sup=path       set suspected quarantine folder
/alev[n]            set maximum archive depth level
/y, /copy            copy suspect files in quarantine
/o, /copy            copy infected files in quarantine
/move               move infected files in quarantine
/moves              move suspect files in quarantine
/flev[n]            set maximum folder depth level
```

4. Command Language



5. Natural Language

# Forming Tasks: Object + Action

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Tasks in a user interface usually have two parts:  
object(s) plus an action on the object(s)

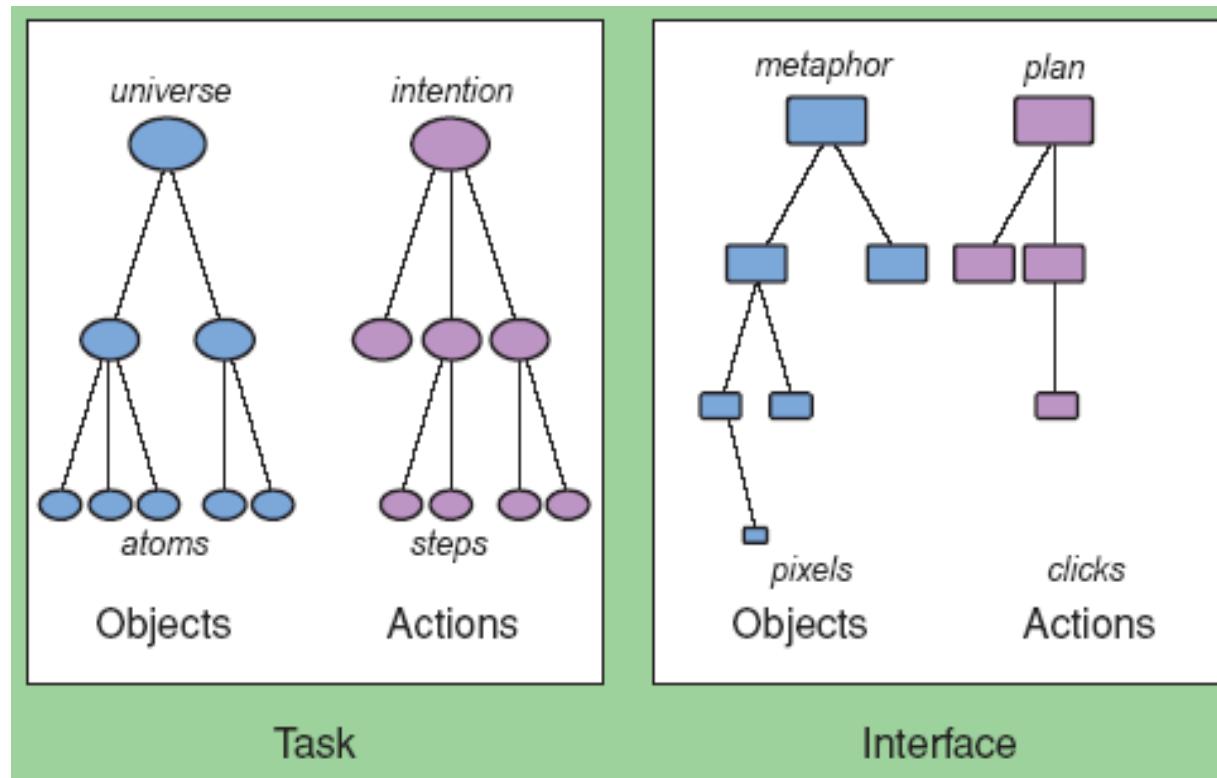


What are the objects in the above examples?  
What are the tasks that we can do on them?

# Forming Tasks: OAI vs AOI models

Object-Action Interface (OAI) vs AOI Model

-> helps explain direct manipulation



```
Z:\>del test.txt  
Unable to delete: test.txt.
```

AOI, e.g.,  
- del test.txt  
- <action> <obj.>



OAI, e.g.,  
- Select a file  
- Move it to trash

How about other interaction styles?

# Interface Style or Paradigms

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After completing the task analysis and identifying task objects and actions, UI designer can choose from these **primary interaction styles** for each task:

1. Direct Manipulation      week 6 (midterm incl.)
2. Menu Selection            week 7 (final incl.)
3. Form filling                week 7 ...
4. Command Language        week 8
5. Natural Language        week 8

Question: Why we say primary?

There are other styles, e.g., brain–computer interface

# Interface Style / Paradigm

Reminder:

- Each interaction style has **pros and cons** (we will discuss after you go through each of them)
- We can also appropriately **mix and use** several of them together in the same interface as well as allowing user to choose a style for performing the same task



1. Direct Manipulation



2. Menu Selection

Required •

Email Address •

Confirm Email Address

Enter a Shipping Address

Address Nickname •  
For example, Home or Work. A nickname will help you locate

3. Form filling

```
C:\WINNT\System32\cmd.exe
Usage: bddosc.exe path[!] [parameters]
Parameters:
  /f files      scan files *      /R, /nor
  /r, /arc      scan archives    /D, /prop
  /i, /mail     scan mail databases /O, /info
  /d, /dis     disinfect files  /U, /nowar
  /h, /noheid   no heuristics   /V, /vlist
  /G, /log=[file] create log file /infext=ext
  /I, /all      log infected files /? , /help
  /e, /all      scan all files   /L, /del
  /e, /app      append to log file /?
  /I, /tmp=[path] set temporary path * = default
  /k, /nopack   don't scan packed programs
  /F, /inf=[path] set infected quarantine folder
  /E, /ext=[ext;ext2;...]
  /U, /suspect   scan on these extensions
  /U, /copypath set suspected quarantine folder
  /A, /lev[=n]   set maximum archive depth level
  /y, /copies   copy suspect files in quarantine
  /o, /copy     copy infected files in quarantine
  /move        move infected files in quarantine
  /moves       move suspect files in quarantine
  /lev[=n]      set maximum folder depth level
```

4. Command Language



Siri

5. Natural Language

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## Topics:

- Introduction: interaction styles
- What is Direct Manipulation (DM)?
- Examples of DM
- Multitouch interactions
- Virtual and Augmented Reality (VR & AR)
- When AI meets VR & AR

# Various Definitions of DM

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**Def 1**: A user interface technique (an interaction style) that lets a user perform tasks by **manipulating objects**.

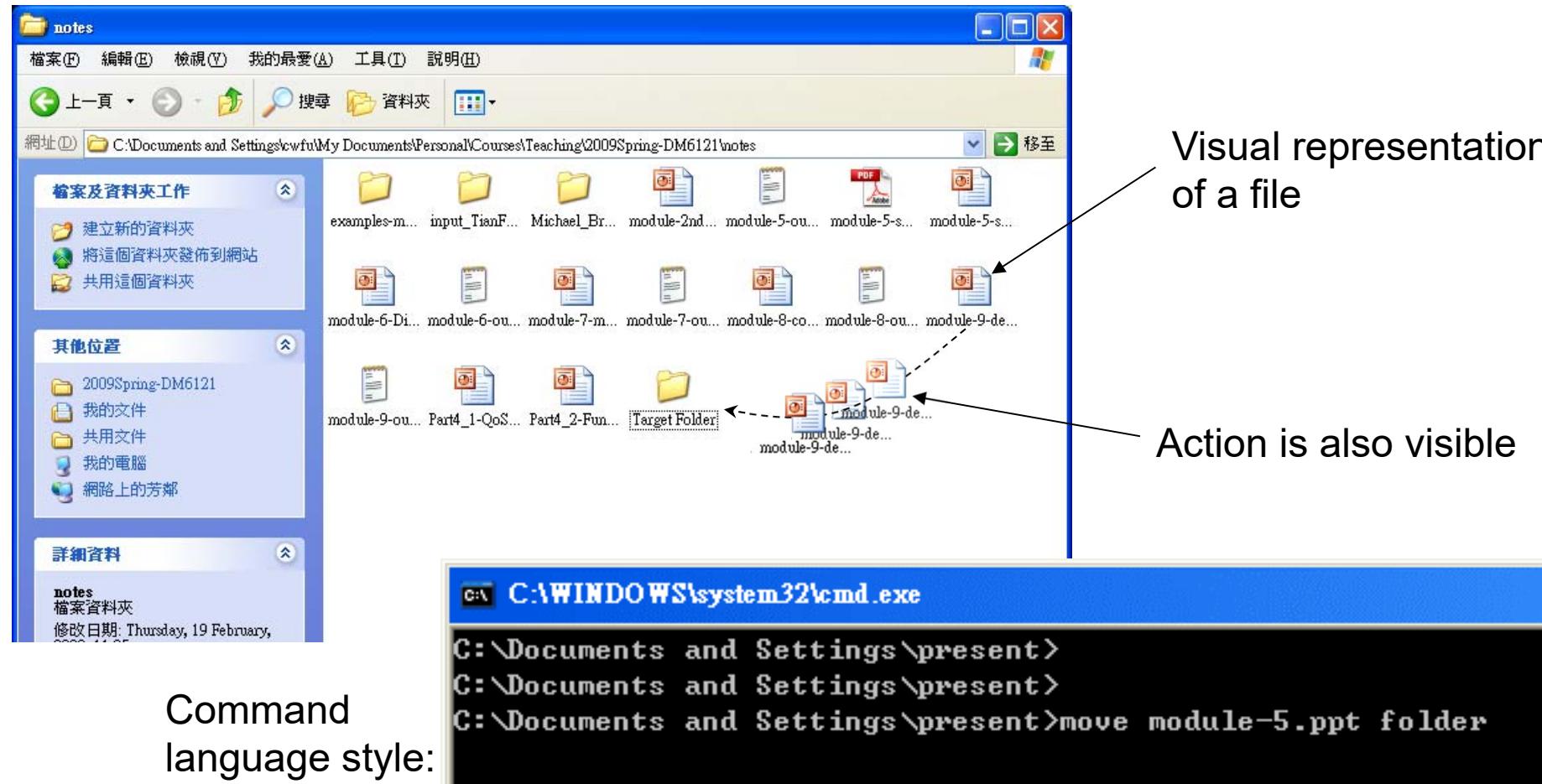
**Def 2** : A direct mapping between the **semantic** level of a dialogue and the **syntactic** level. The syntax of operations should correspond to a **metaphor** of the semantic change in the data and the screen **representation of objects** should mirror their internal state.

**Def 3** : a human–computer interaction style which involves continuous representation of **objects** of interest and rapid, reversible, and incremental **actions and feedback** (from wiki)

**Def 4**: Direct manipulation is an interaction style in which the **objects of interest in the UI are visible** and can be acted upon via **physical, reversible, incremental actions** that receive immediate feedback (from <https://www.nngroup.com/articles/direct-manipulation/>)

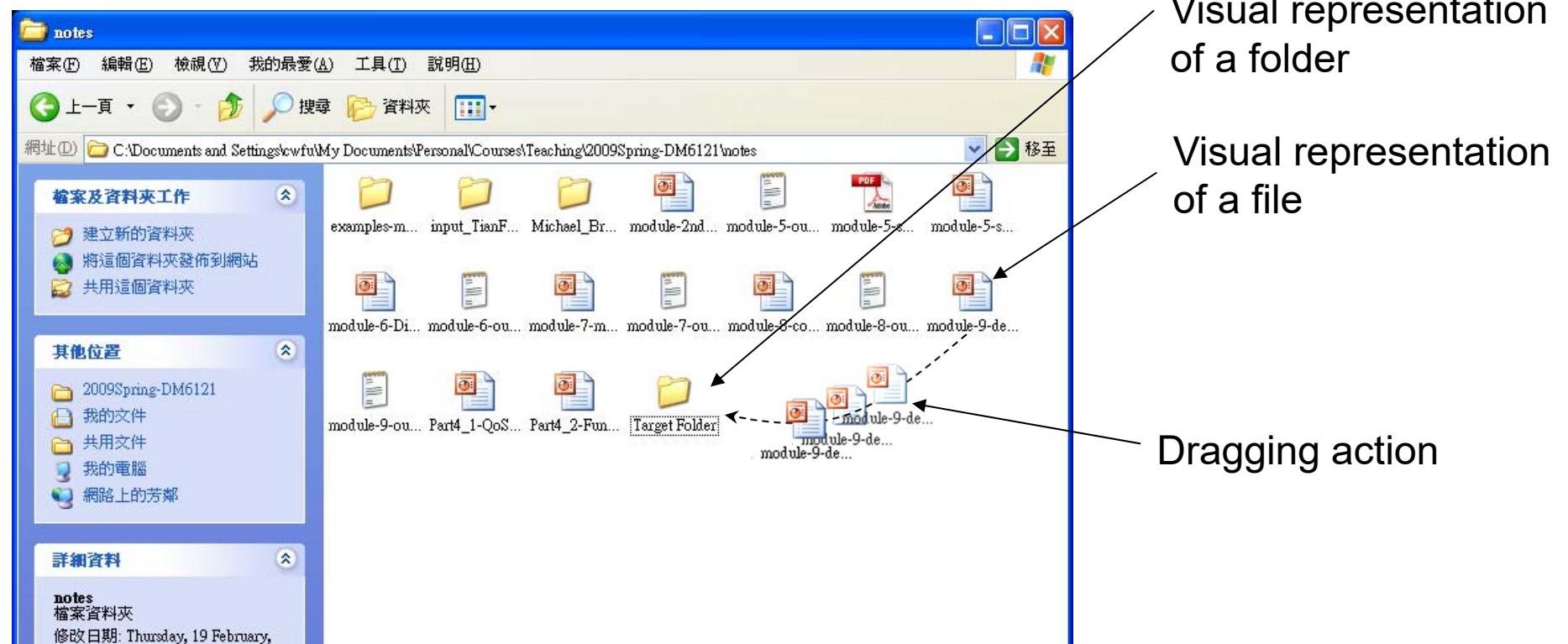
# A Classic Example of DM

Example: Moving a file to another folder / trash



# A Classic Example of DM

Example: Moving a file from one folder to another



# A Widely-used Example of DM

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Example: Manipulating Photos on phone by touch



# Definition of Direct Manipulation

Direct Manipulation (1988 University of Maryland UIS Broadcast)

**DIRECT MANIPULATION**

Visual representation of the "world of action"

- Objects & Actions are shown
- Taps analogical reasoning

Rapid, incremental, and reversible actions

Replace typing with pointing/selecting

Immediate visibility of results of actions

**Benefits**

- Control/directness
- Less syntax
- Faster learning

0:41 / 3:05

<http://www.youtube.com/watch?v=CWgPe8VjTsM>

(as is the text book, by its author Ben Shneiderman)

# Definition of Direct Manipulation

## Direct Manipulation: Definition

**Summary:** Direct manipulation is an interaction style in which the objects of interest in the UI are visible and can be acted upon via physical, reversible, incremental actions that receive immediate feedback.

By Samyukta  
Topics: Human-computer interaction

**Summary:** Direct manipulation is an interaction style in which the objects of interest in the UI are visible and can be acted upon via physical, reversible, incremental actions that receive immediate feedback.

Let's say that you're looking at an image of yourself on a roller coaster and want to see if your terrified expression has been caught on camera. What do you do? Something like this?



<https://www.nngroup.com/articles/direct-manipulation/>

# Direct-Manipulation Interface

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Three principles:

- Continuous and visible representation of the objects and actions of interest;
- Rapid, incremental, and reversible actions whose effect on the object of interest is immediately visible;
- Replacement of typed commands (no syntax) by a pointing action on the object of interest

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## Topics:

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# Examples of DM

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Many people nowadays know how to perform DM



# Before Direct Manipulation

```
C:\>dir  
Volume in drive C has no label.  
Volume Serial Number is 8CE2-D369
```

```
Directory of C:\
```

```
09/25/2006  01:08 PM           24 autoexec.bat  
09/25/2006  01:08 PM           18 config.sys  
10/13/2006  01:43 PM  <DIR>      DELL  
01/05/2002  02:38 AM          54,784 msvc170.dll  
10/17/2006  01:41 AM  <DIR>      Perl  
10/29/2006  11:41 PM  <DIR>      Program Files  
10/13/2006  04:41 PM  <DIR>      ProgramDataTechSmith  
10/13/2006  02:24 PM  <DIR>      Users  
10/21/2006  06:04 PM  <DIR>      Windows  
10/13/2006  05:58 PM  <DIR>      Windows.old  
10/13/2006  03:40 PM          146 YServer.txt  
                           4 File(s)       54,964 bytes  
                           7 Dir(s)   24,839,090,176 bytes free
```

```
C:\>ls -l  
ls: reading directory .: Permission denied
```

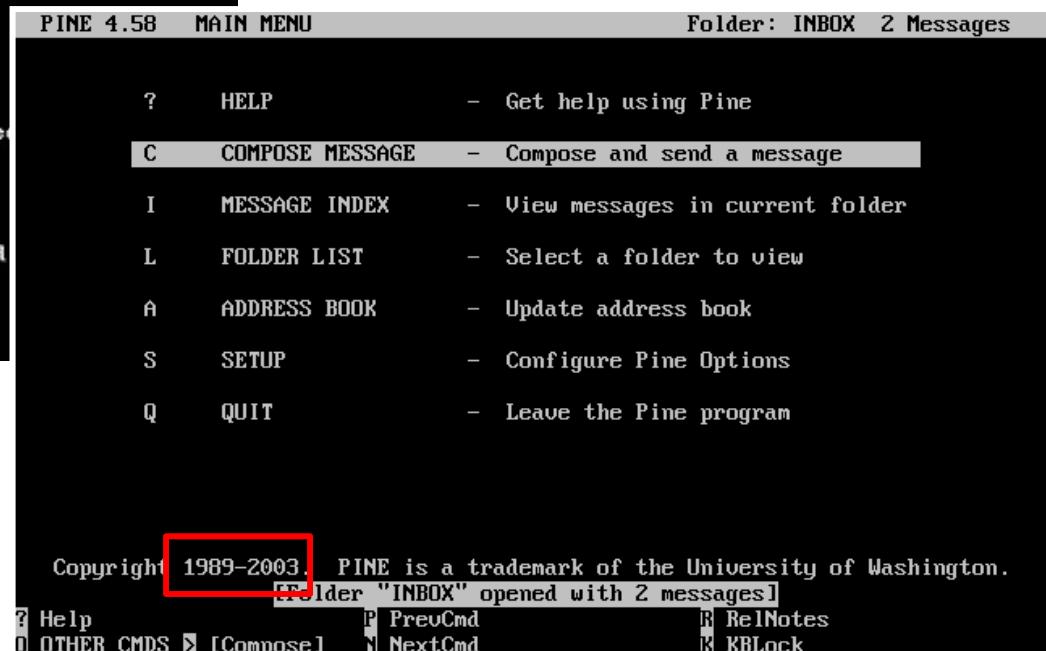
```
total 472  
drw-rw-rw-  5 Ajit 0  4096 2006-10-13 15:24 $Recycle.Bin  
-rwxrwxrwx  1 Ajit 0  24 2006-09-25 14:08 autoexec.bat  
drw-rw-rw-  26 Ajit 0  4096 2006-10-13 19:07 Boot  
-rw-rw-rw-  1 Ajit 0  353 2006-10-13 14:57 Boot.BAK  
-r--r--r--  1 Ajit 0  353 2006-10-13 19:07 Boot.ini.save  
-r--r--r--  1 Ajit 0  438328 2006-10-04 03:02 bootmgr  
-r--r--r--  1 Ajit 0  8192 2006-10-13 19:07 BOOTSECT.BAK  
drw-rw-rw-  2 Ajit 0  0 2006-10-24 23:34 Config.Msi  
-rw-rw-rw-  2 Ajit 0  10 2006-09-25 14:08 config.sys  
drw-rw-rw-  3 Ajit 0  4096 2006-10-13 14:43 DELL  
dr--r--r--  2 Ajit 0  4096 2006-10-13 15:24 Documents and
```

```
C:\>
```



Command prompt

PINE – Check email



1989-2003.

# Direct Manipulation

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- For computers, started with the move from *pure text-based interfaces* to *graphics-based interfaces*:
  - WIMP: W [ ] ; I [ ] ; M [ ] , and P [ ]
  - And further to more direct manipulation interfaces
- Supported by two important advancements:
  - Graphics got better (higher quality and resolution: monochrome -> EGA -> VGA -> ..... ) and faster
  - The addition of an input device: the “mouse” (and more recently, multitouch and AR)



First mouse . . Developed by Douglas C. Englebart in 1968 while working at Stanford Research Institute (SRI).

He gave a demo that has been called the “Mother of all Demos”. He demonstrated a mouse used in word processing (among other things).

The mouse was popularized by the Apple Macintosh as “standard equipment”.

# Direct Manipulation

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- “Great Leap Forward”
- DM changed existing applications
  - Word processing
  - Spread-sheets
  - Drawing Programs and CAD, etc.
- DM blossomed via Video Games
  - Console games
  - PC games
- Beyond the 2D desktop via VR and AR

# DM Systems (word processing)

## Example 1: Word Processing (Document)

Command line vs. display editors and word processors

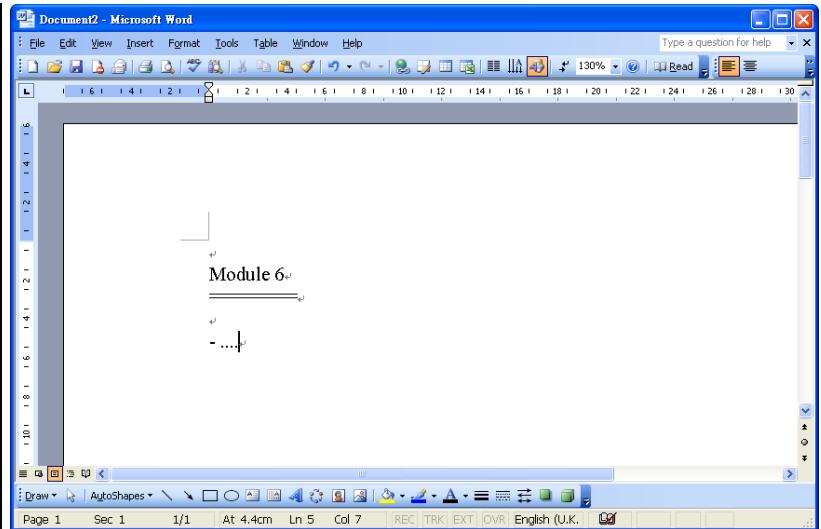
```
#!/bin/ksh

10dd
functionA() {
# code block in functionA starts
#
#
#
#
#
#
#
#
#
# code block in functionA starts
}

# run functionA
functionA

# exit script
exit 0
```

INPUT MODE



vi editor in Unix & Linux (original 1976)

<https://en.wikipedia.org/wiki/Vi>

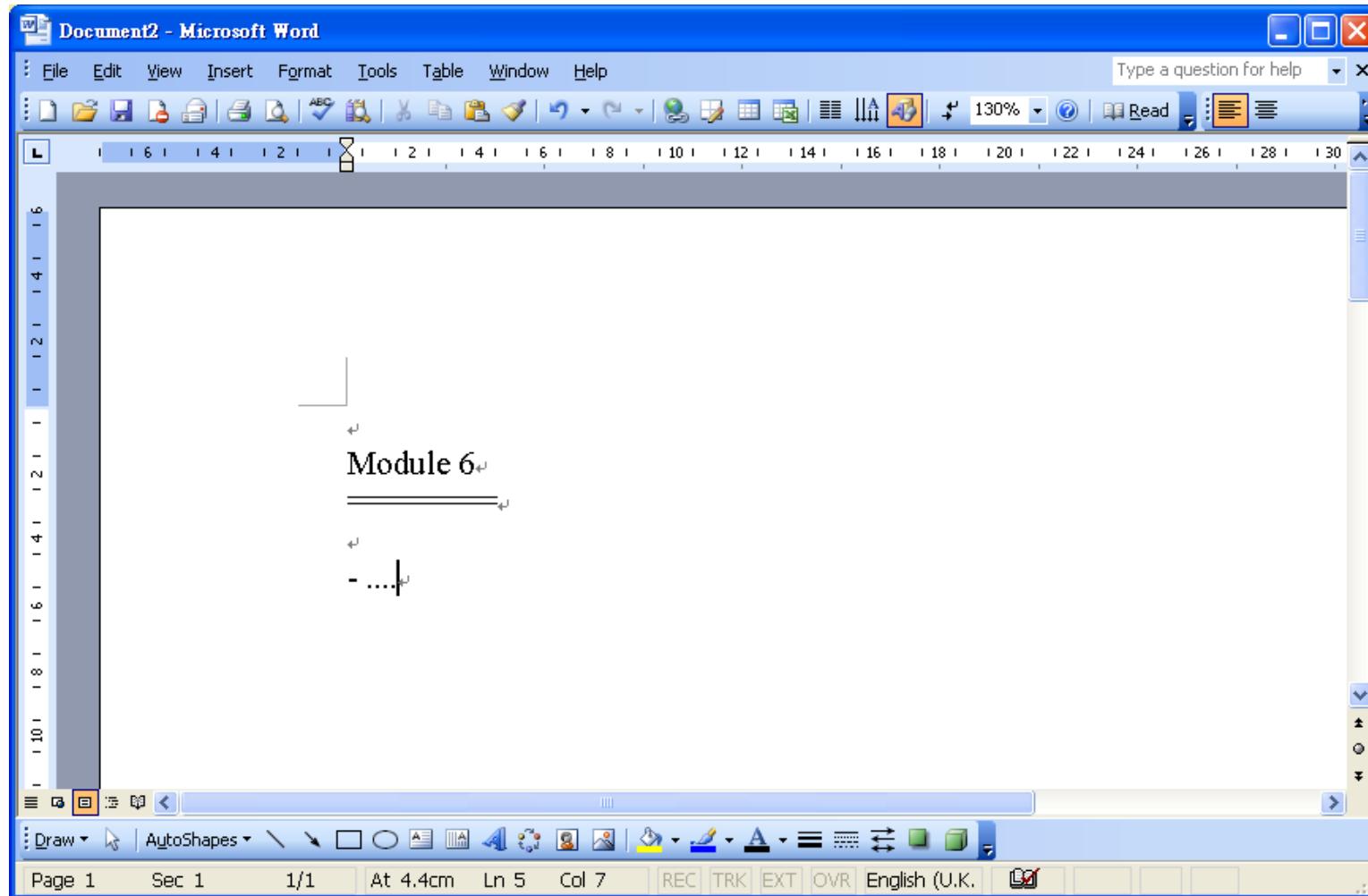
MS Office – Word 2003

WYSIWYG word processors

(What You See Is What You Get)

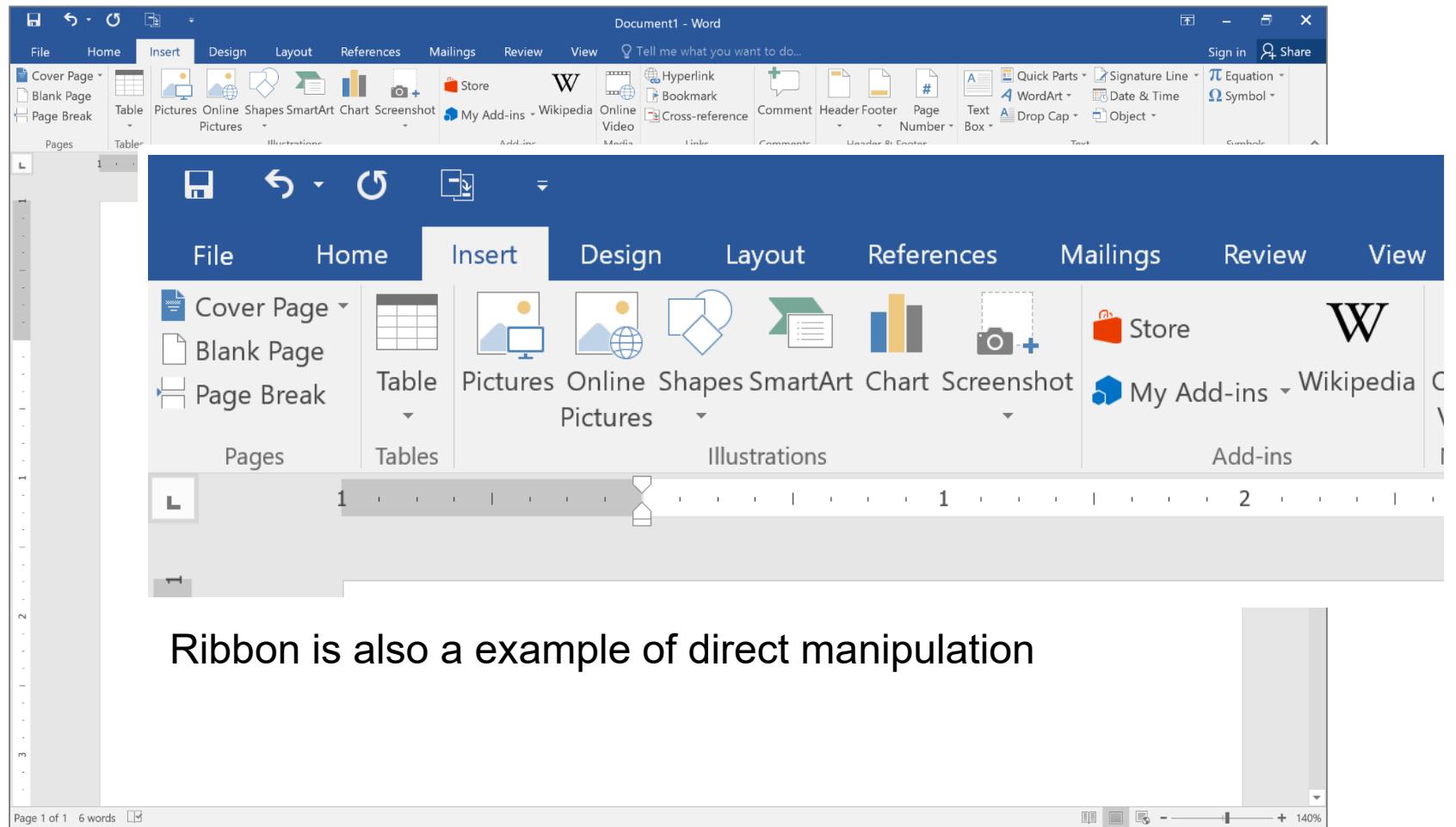
# DM (word processing: display editor)

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**MS Office – Word 2003**

# DM (word processing: display editor)



Ribbon is also a example of direct manipulation

# Examples of DM Systems (cont.)

## Example 2: Spread sheets

Excel 2003

A:A1: 'EMP						
Worksheet Range Copy Move File Print Graph Data System Quit						
Global Insert Delete Column Erase Titles Window Status Page Hide						
A	A	B	C	D	E	F
1	EMP	EMP_NAME	DEPTNO	JOB	YEARS	SALARY
2	1777	Azibad	4000	Sales	2	40000
3	81964	Brown	6000	Sales	3	45000
4	40378	Burns	6000	Mgr	4	75000
5	50706	Caeser	7000	Mgr	3	65000
6	49692	Curly	3000	Mgr	5	65000
7	34791	Dabarrett	7000	Sales	2	45000
8	84984	Daniels	1000	President	8	150000
9	59937	Dempsey	3000	Sales	3	40000
10	51515	Donovan	3000	Sales	2	30000
11	48338	Fields	4000	Mgr	5	70000
12	91574	Fiklore	1000	Admin	8	35000
13	64596	Fine	5000	Mgr	3	75000
14	13729	Green	1000	Mgr	5	90000
15	55957	Hermann	4000	Sales	4	50000
16	31619	Hodgedon	5000	Sales	2	40000
17	1773	Howard	2000	Mgr	3	80000
18	2165	Hugh	1000	Admin	5	30000
19	23987	Johnson	1000	VP	1	100000
20	7166	Lafflare	2000	Sales	2	35000
DATA.WK3						

Lotus 1-2-3 (1990')

The screenshot shows a Microsoft Excel 2003 window titled "Microsoft Excel - Budget.xls". The spreadsheet contains data for operating expenses across four quarters (Q1-Q3) for various categories like Salaries, Supplies, Equipment, Lease Pmts, and Advertising. A formula bar at the top shows the formula =SUM(E11:E15). The ribbon menu is visible, and the formula bar shows '=SUM(E11:E15)'.

	A	B	C	D	E	F	G	H	I	J	K
1											
2	Site	Operating Exp	GL#	Jul-03	Aug-03	Sep-03	Q1	Q2	Q3		
3	Albany, NY			\$28,675	\$28,175	\$28,675	\$53,475	\$53,675	\$85,525		
4		Salaries	1-1002	10000	10000	10000	30000	30000	30000		
5		Supplies	1-2310	3000	2500	3000	7800	8000	8500		
6		Equipment	1-2543	4575	4575	4575	4575	4575	13725		
7		Lease Pmts	1-7862	9600	9600	9600	9600	9600	28800		
8		Advertising	1-8752	1500	1500	1500	1500	1500	4500		
9											

The screenshot also shows a separate calendar table below:

	A	B	C	D	E	F	G	H	I	J	K
1				M	T	W	Th	F			
2		Jan	week 1	6	7	8	9	10			
3			week 2	13	14	15	16	17			
4			week 3	20	21	22	23	24			
5		Feb		27	28	29	30	31			
6				3	4	5	6	7			
7				10	11	12	13	14			
8			week 4	17	18	19	20	21			
9			week 5	24	25	26	27	28			
10		Mar	week 6	2	3	4	5	6			

Annotations in the calendar table:

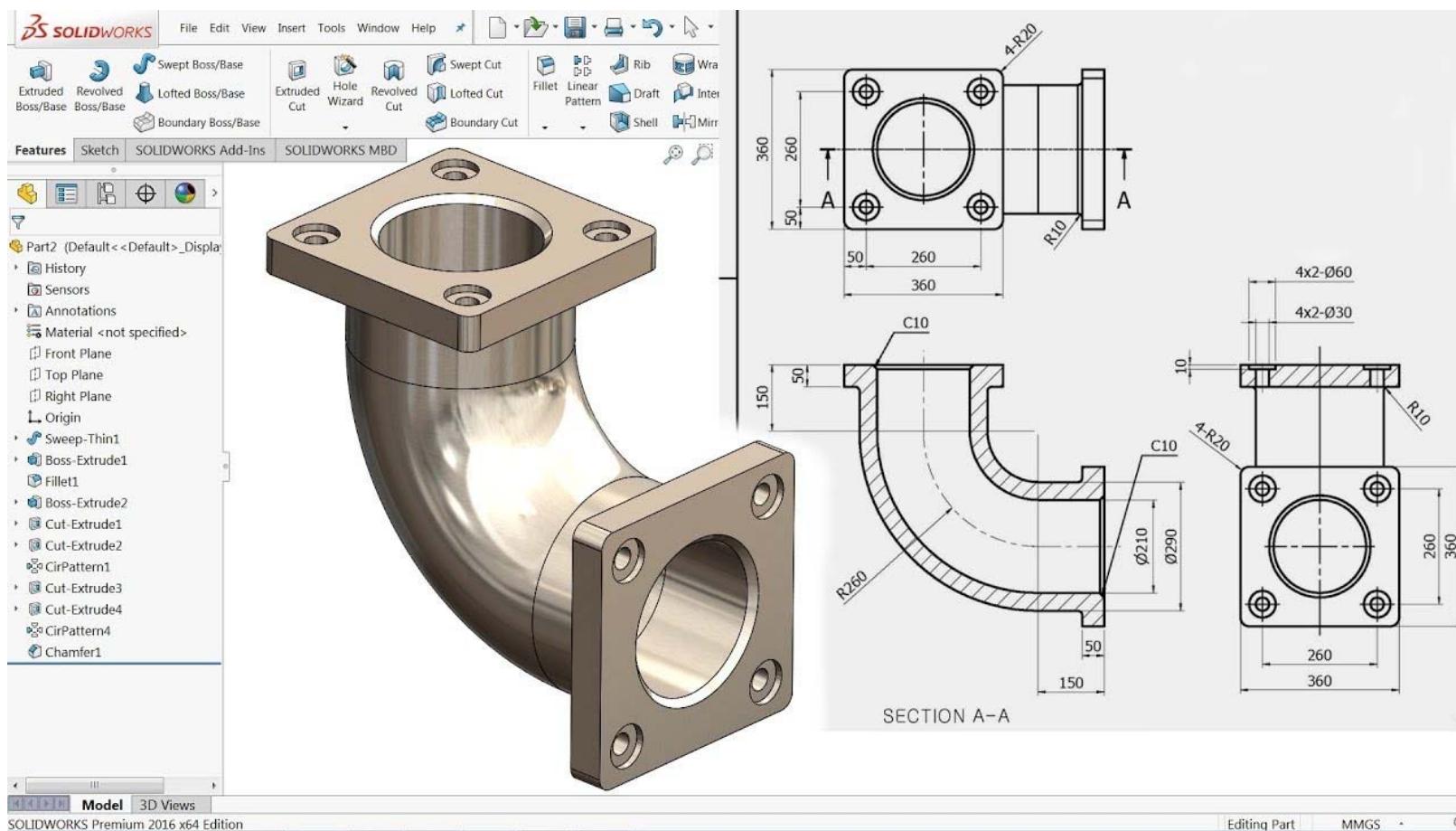
- Jan 14: Asg 1 distributed
- CNY holidays: Jan 24 - Feb 14
- Feb 3: Asg 1 due
- Feb 21: Asg 2 distributed

Excel Nowadays

# Examples of DM Systems (cont.)

## Example 3: Computer-aided design

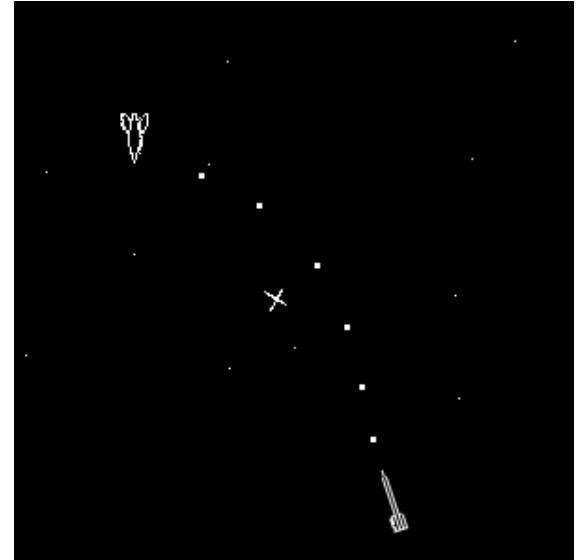
- Manipulate 3D object of interest
- Graphical icons, dimensions, etc.



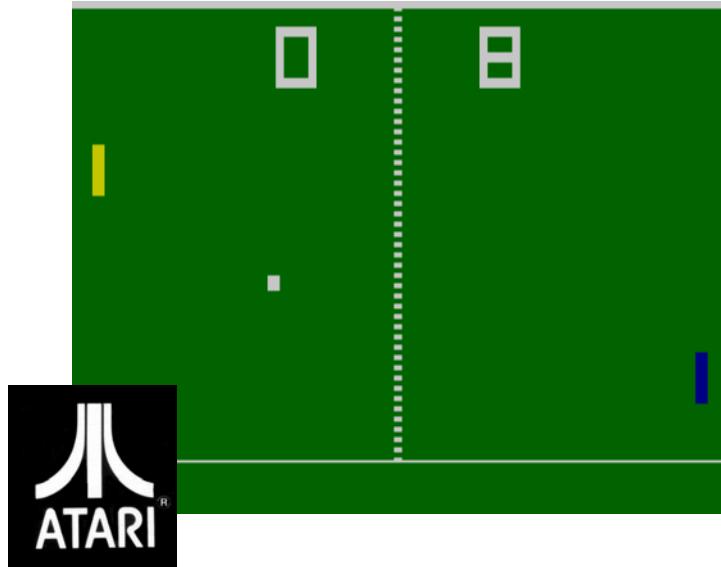
# Video Games: Brief Review

## Example 4: Video Games

- 1962: MIT student Steve Russel created *Spacewar*, the first interactive computer game; its platform: a DEC PDP-1



Java applet: <http://spacewar.oversigma.com/>



1972: Bushnell, who designed *Computer Space* (1st arcade game) formed **Atari**. Their first product “Pong,” which simulates ping-pong

<https://en.wikipedia.org/wiki/Pong>

# Video Games: Brief Review

1978: **Midway** - Space Invader



1979: Namco - **Pac-man**

1983: Nintendo **Famicom**:

Nintendo Entertainment System (**NES**):

- **Mario Bros**: 1983,
- **Super Mario Bros.**: 1985



# Video Games

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Final Fantasy, PS4



Mario Kart 8



Final Fantasy 1, 1987



Mario 1 (NES)

# Video Games

- Direct Manipulation with Controllers



Sensing



Knife

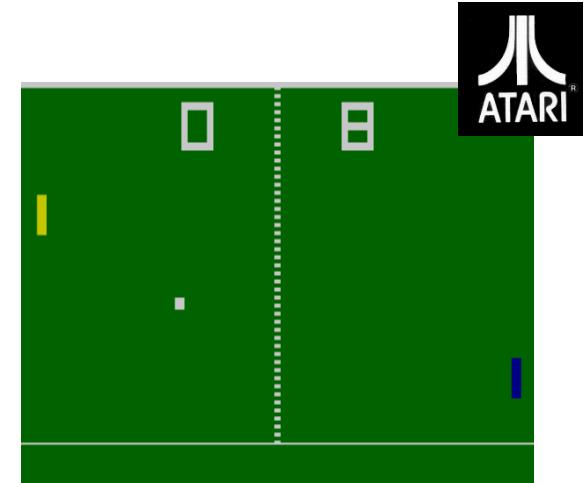
Manipulating the controller  
as if you are manipulating  
the virtual knife!!!



# Examples of DM Systems (cont.)

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- From PONG to Nintendo Switch and Sony PlayStation 5
- Field of action is **visual** and compelling
- Commands are **physical actions** whose results are **immediately shown** on the screen
- **No syntax** to remember
- Most games **continuously** display a score (and action)
- Direct manipulation in Animal Crossing



Animal Crossing

# Recall...

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Recall the three principles of DM

-> Are they applicable to video games?

- Click and drag representation of the objects and actions of interest;
- Rapid, incremental, and reversible actions whose effect on the object of interest is immediately visible;
- Replacement of typed commands (no syntax) by a pointing action on the object of interest

# Discussion of Direct Manipulation

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## Beneficial attributes:

- Novices learn quickly
- Expert and intermittent users can retain concepts
- Error messages are rarely needed
- Users see if their actions are furthering (moving toward) their goals (since graphical and easy-to-recognize)
- Users experience less anxiety
- Users gain confidence and mastery

# Discussion of Direct Manipulation

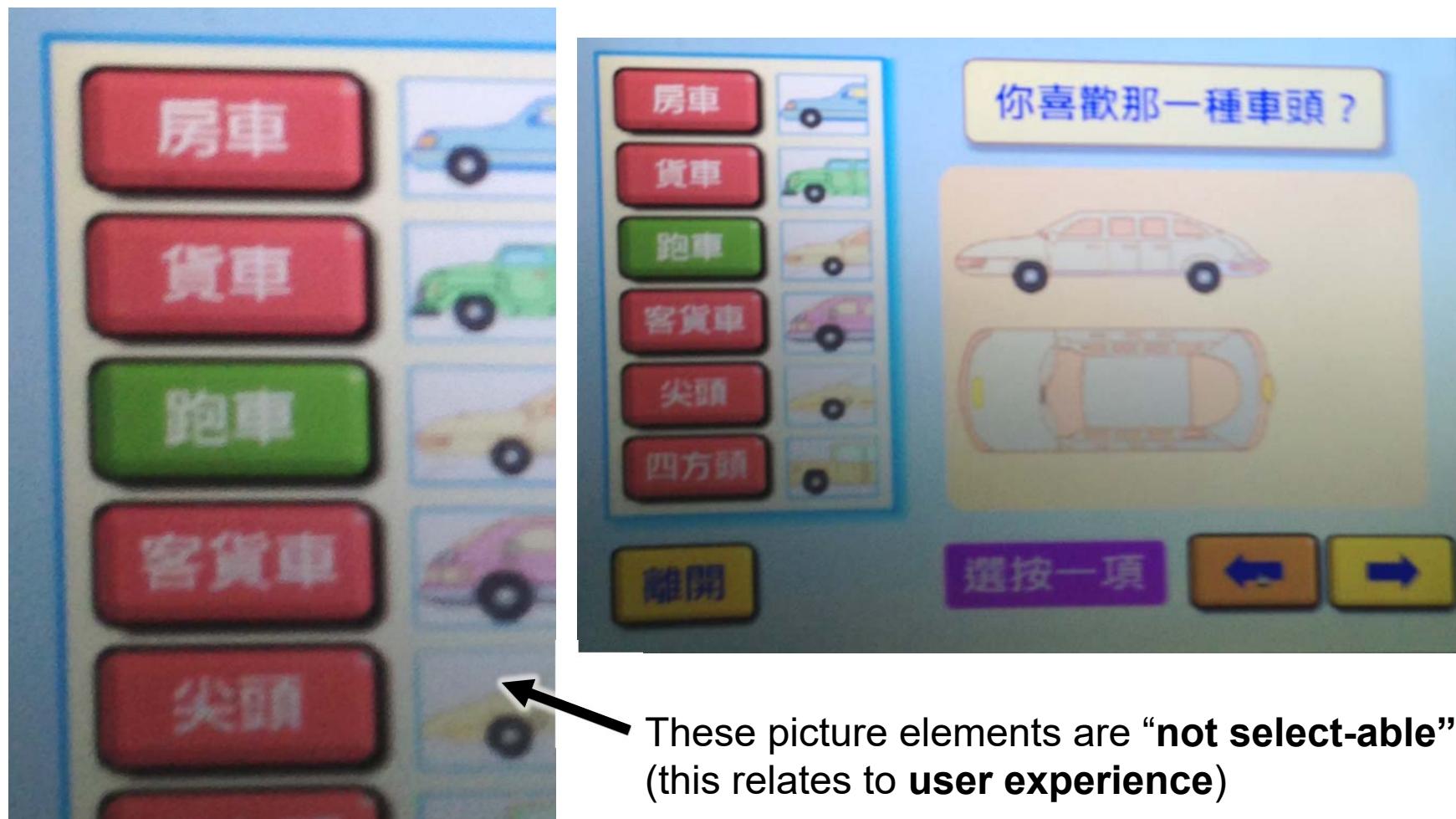
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## Problems with direct manipulation

- Spatial or visual representations can be too spread out (i.e., occupying lots of **screen space**)
- Users **must learn (or know) the semantics** behind the graphical representations; otherwise, the visual representation may be misleading
- It **requires a good design of the representations**, while a good representation is not always easy to design
- **Typing** commands (particularly by using short-cut keys) with the keyboard may be faster
  - Mouse motions take time and require a stop in typing
- **Repetitive** tasks not well supported
- Some gestures can be more **error-prone** than typing,
  - e.g., select the 35<sup>th</sup> letter in the 10<sup>rd</sup> row

# Direct-Manipulation Interface

Example: users want to touch and directly manipulate graphical elements in an UI, but if...



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## Topics:

- Introduction: interaction styles
- What is Direct Manipulation (DM)?
- Examples of DM
- Multitouch interactions
- Virtual and Augmented Reality (VR & AR)
- When AI meets VR & AR

# Multitouch Interaction

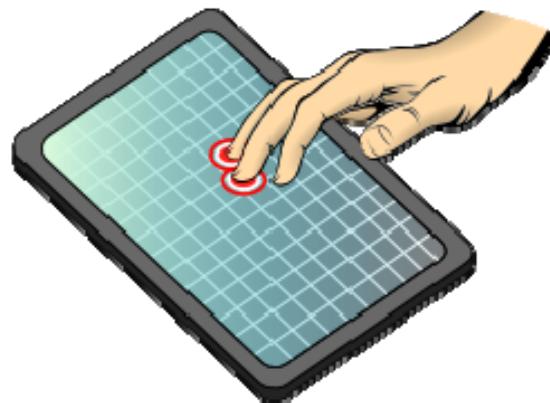
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- **What is Multitouch?**

A user interaction technique typically used to manipulate graphical entities with multiple fingers at the same time.

- **Generalization of touchscreen:**

- Not just one point
- Not just tapping, but just motion over the screen
- So, we can have gestures for different usage (improve the expressiveness vs. single touch)



History of multitouch: <http://www.billbuxton.com/multitouchOverview.html>

# Multitouch Interaction

- Gestures... many variations...
  - Degrees of freedom (number of touch points)
  - Touch only or with motion

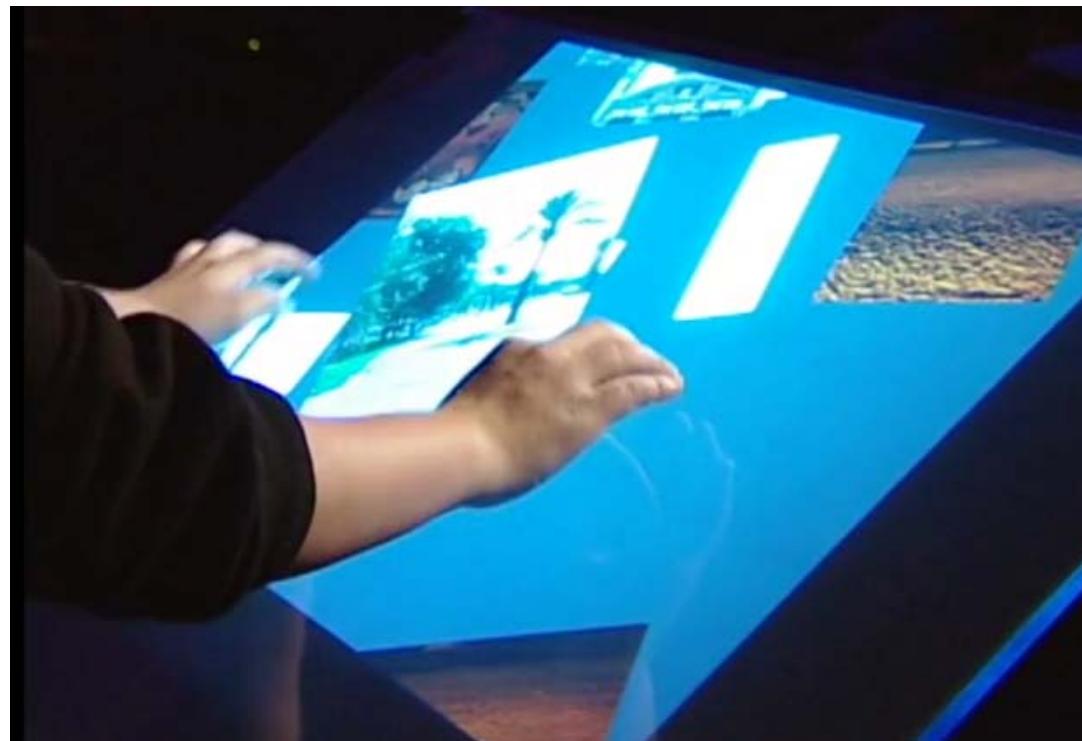


# Multitouch for Direct Manipulation

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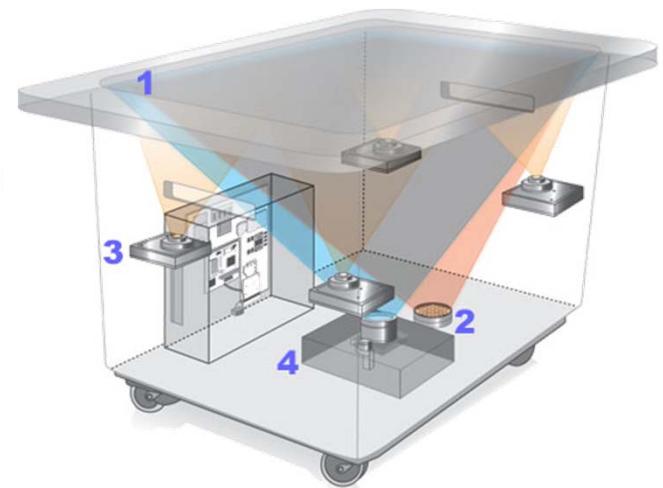
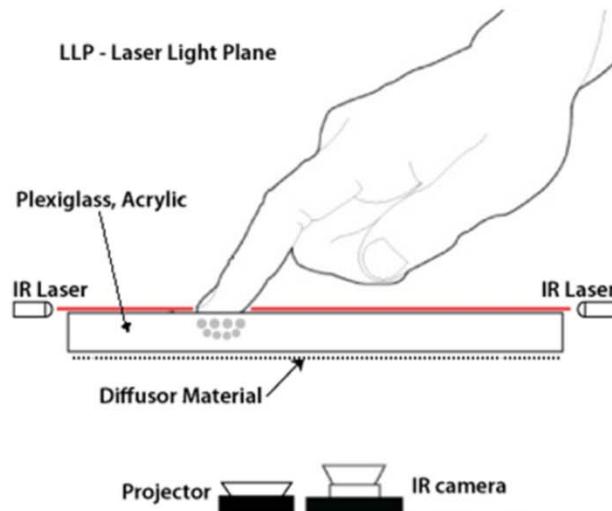
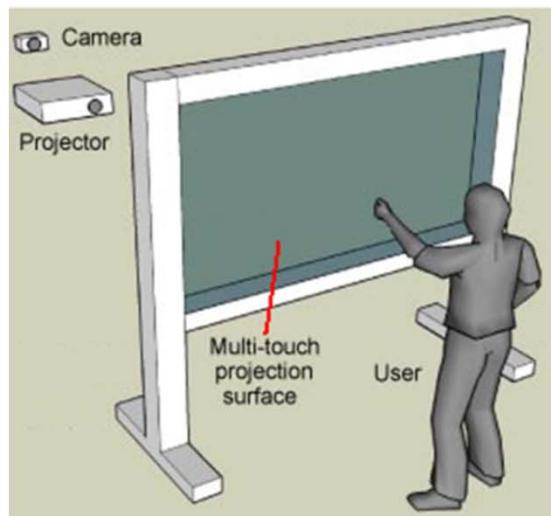
- Any interesting application?
  - A TED demo by Jeff Han of Perceptive Pixel, 2006:

[https://www.ted.com/talks/jeff\\_han\\_demos\\_his\\_breakthrough\\_touchscreen](https://www.ted.com/talks/jeff_han_demos_his_breakthrough_touchscreen)



# Multitouch Interaction

- How? Two common approaches  
1) Optical approach: camera and image processing



Microsoft Surface, 2001

[https://en.wikipedia.org/wiki/Microsoft\\_PixelSense](https://en.wikipedia.org/wiki/Microsoft_PixelSense)



[http://www.cse.cuhk.edu.hk/~cwfу/papers/multitouch\\_nav/index.htm](http://www.cse.cuhk.edu.hk/~cwfу/papers/multitouch_nav/index.htm)

# Multitouch Interaction

- How? Two common approaches
  - 2) Projected Capacitive Touch (PCT)
    - Transparent conductive material behind the glass
    - Touch affects the screen's electrical field

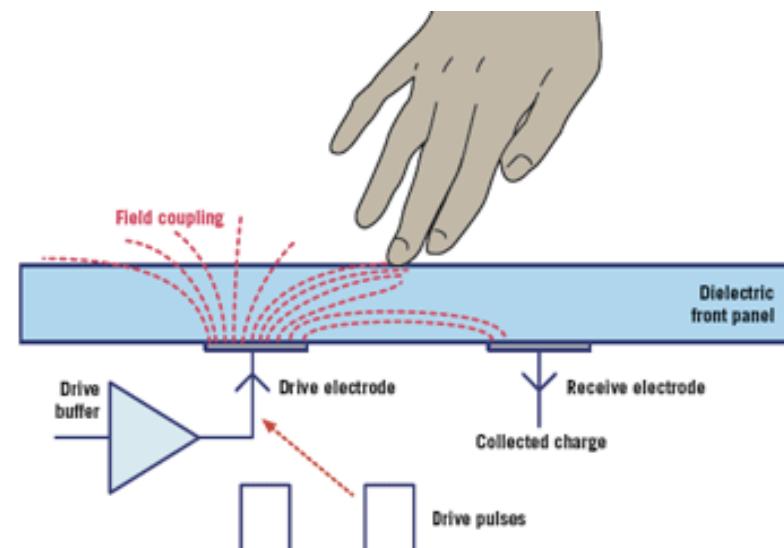


Figure 1



capacitive touchscreens

# Multitouch Interaction

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- Issues with existing Multitouch
  - Fat finger -> precision
  - Cannot distinguish which hand and which finger(s) that trigger the touch
  - No above-surface 3D posture information
- Recent advances: Pressure-sensitive
  - E.g., Force Touch and 3D Touch
- More on Multitouch:
  - <http://www.billbuxton.com/multitouchOverview.html>

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## Topics:

- Introduction: interaction styles
- What is Direct Manipulation (DM)?
- Examples of DM
- Multitouch interactions
- Virtual and Augmented Reality (VR & AR)
- When AI meets VR & AR

# Virtual & Augmented Reality (VR & AR)

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## Contents

- (1) What is Virtual Reality
- (2) What is Augmented Reality
  - Spatial AR
  - See-through AR (Handheld and Glass-based)
- (3) Reality-virtuality continuum (AR <-> VR)

# (1) What is Virtual Reality?

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Virtual Reality, or in short VR, creates a simulated 3D virtual world, where the user feels \*\*\*like\*\*\* **being inside another world**

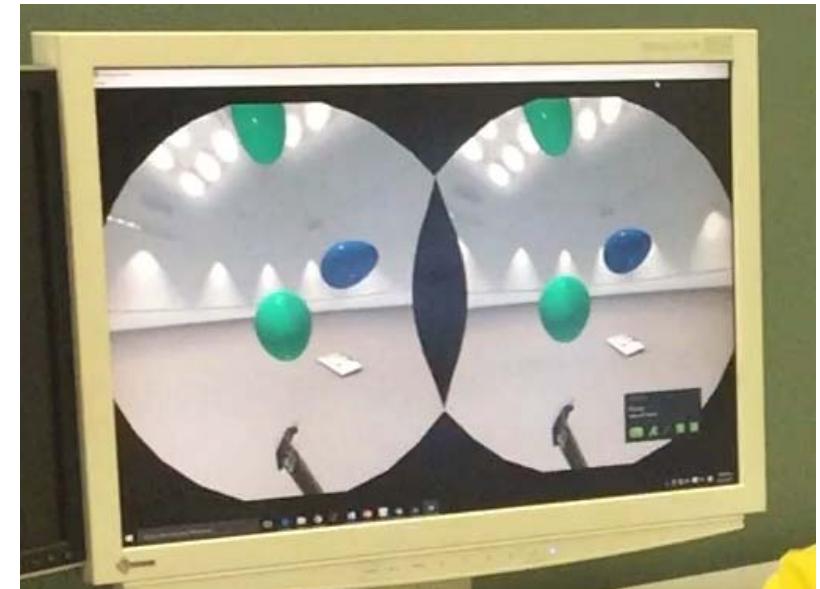
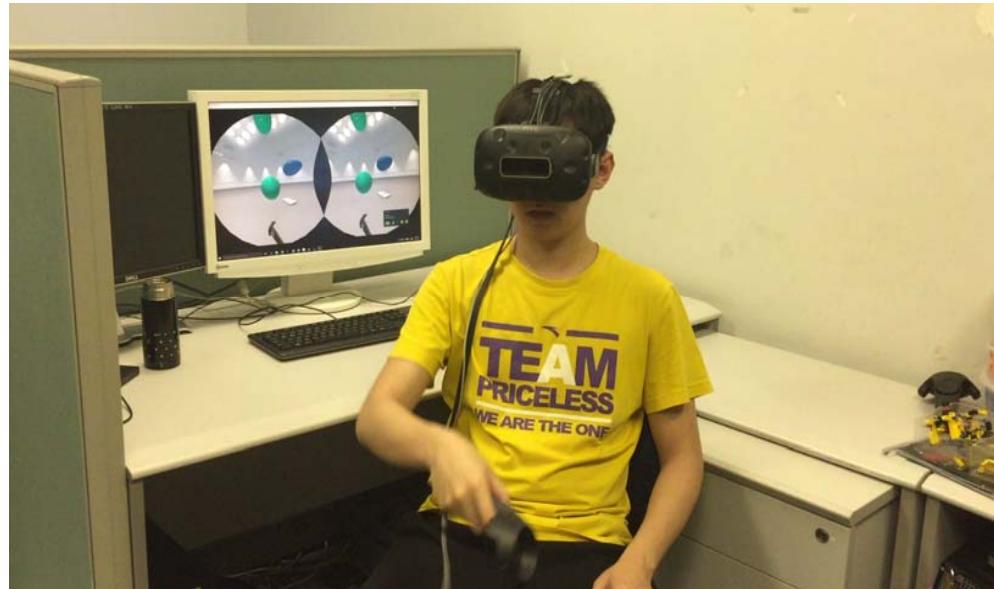


To achieve so, we first have to fill “**user’s vision**” with VR contents...

# (1) What is Virtual Reality?

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Virtual Reality, or in short VR, creates a simulated 3D virtual world, where the user feels \*\*\*like\*\*\* **being inside another world**



# VR Equipment: HMD

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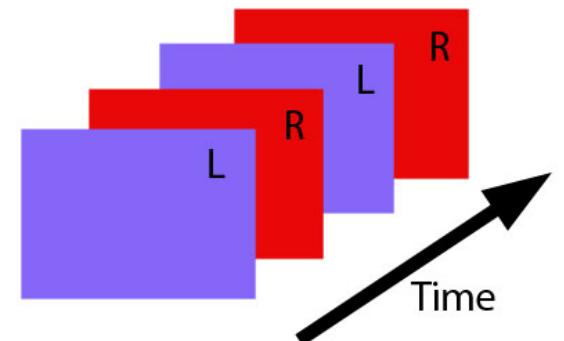


E.g., HMD (Head-mounted display)  
track orientation of user's head

# VR Equipment

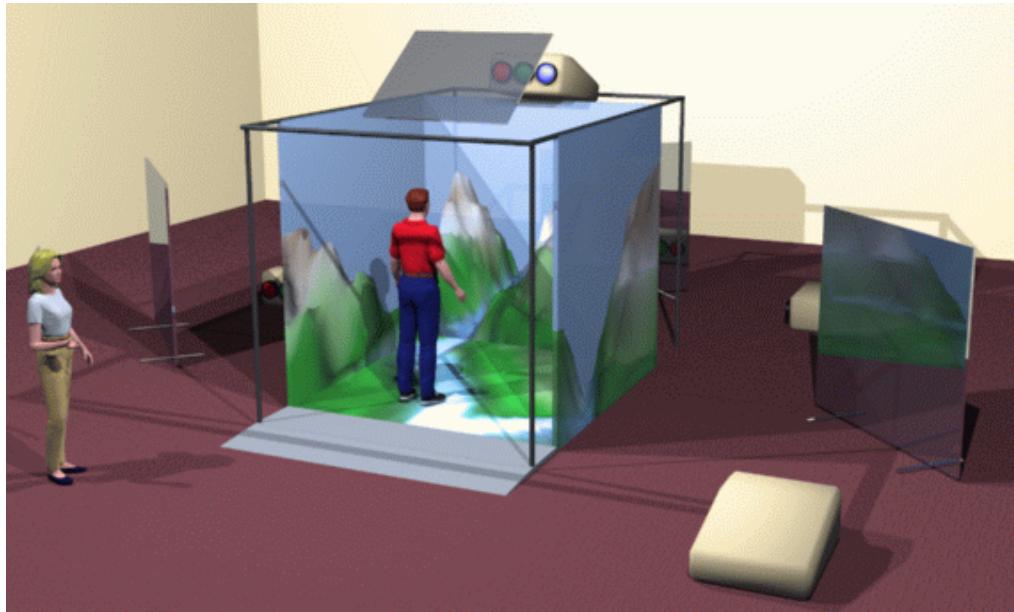


Shuttle glass (or Head-mounted display)  
track orientation of user's head and  
synchronize shuttle with renderings  
Cyberglove – track/sense hand gesture



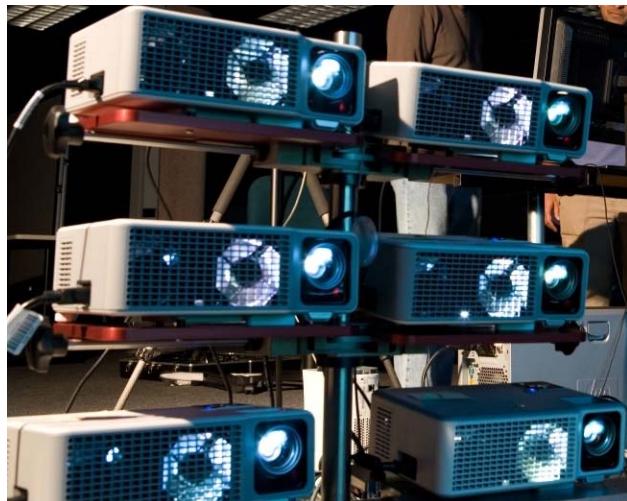
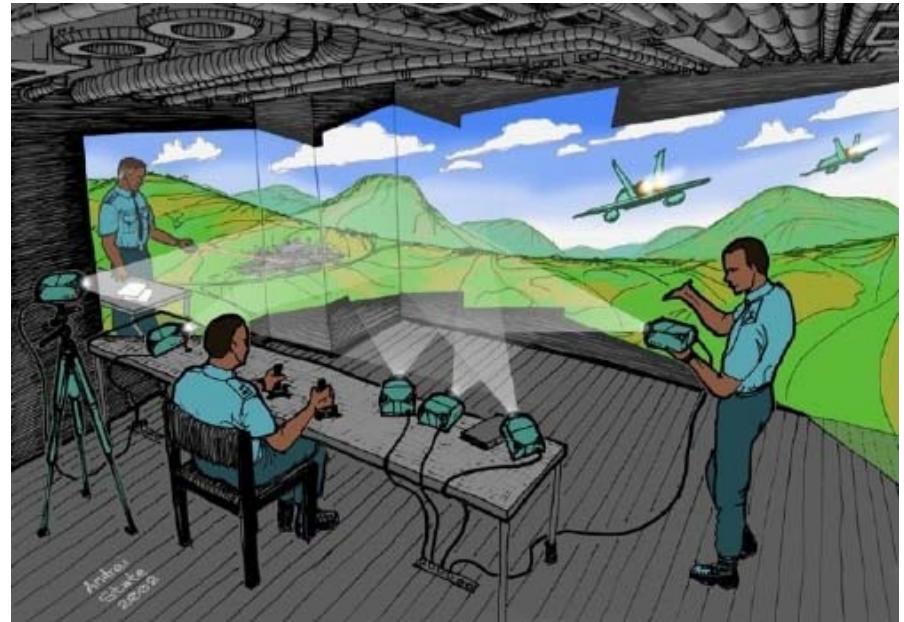
# VR Equipment: CAVE

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CAVE: Cave Automatic Virtual Environment  
(better known by the recursive acronym CAVE)

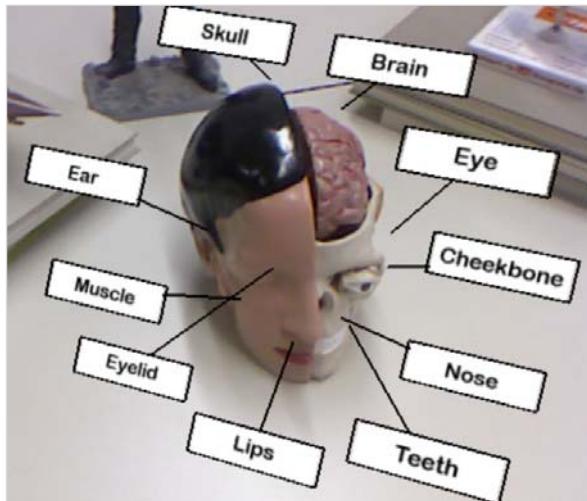
# VR Equipment: Multiprojector display



Video Wall – Multiprojector display

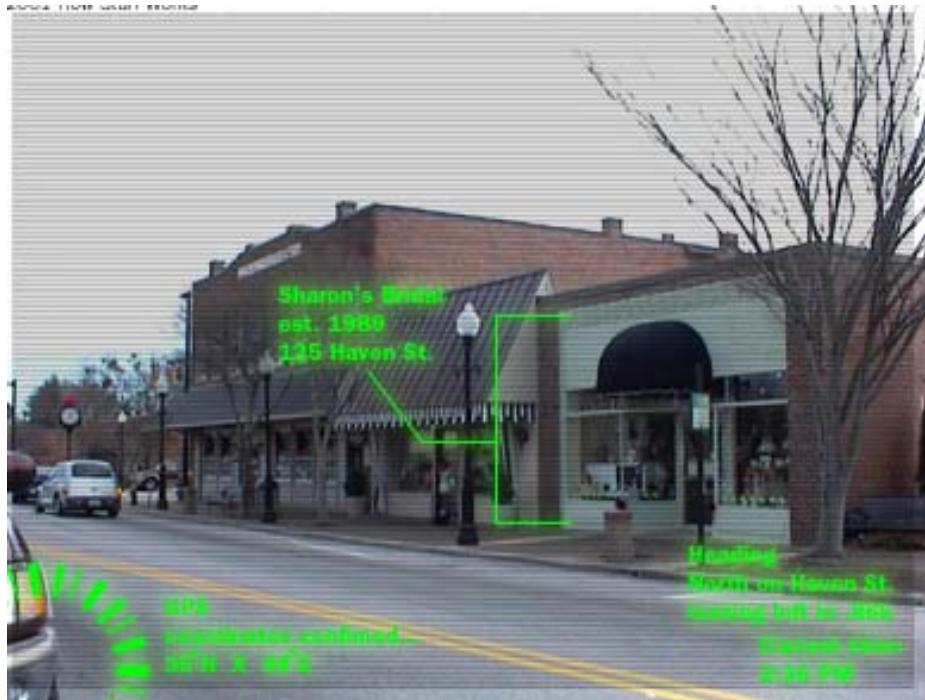
# (2) What is Augmented Reality?

- Situational/Spatial awareness of the environment and objects in the real world
- Enables users to see the real world with an overlay of additional (interactive) information



# Some AR Examples

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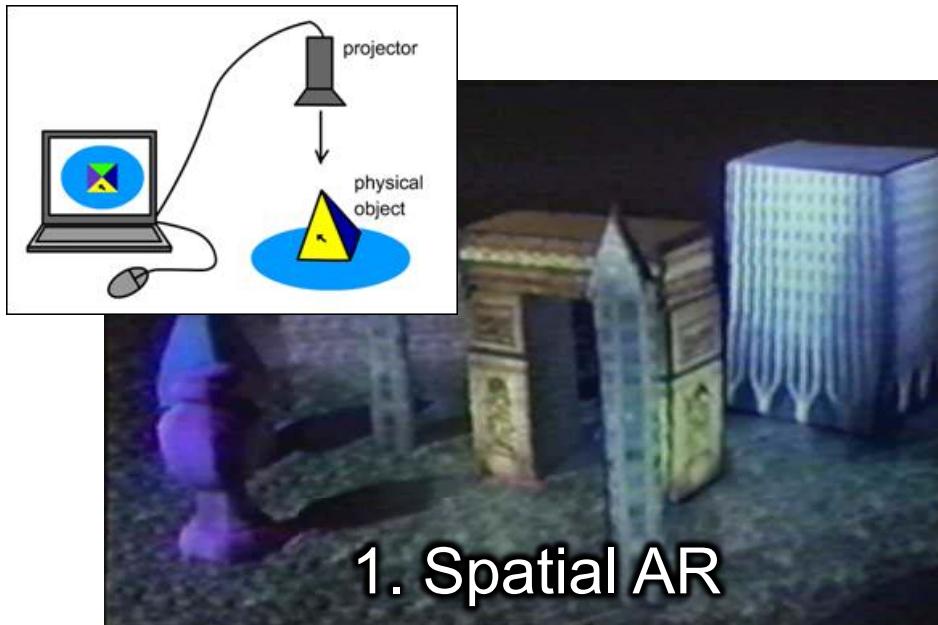
Car windshield augmentation



LEGO box with AR:  
<https://www.youtube.com/watch?v=PGu0N3eL2D0>

# Two approaches for AR

In general, there are two approaches to achieve AR:



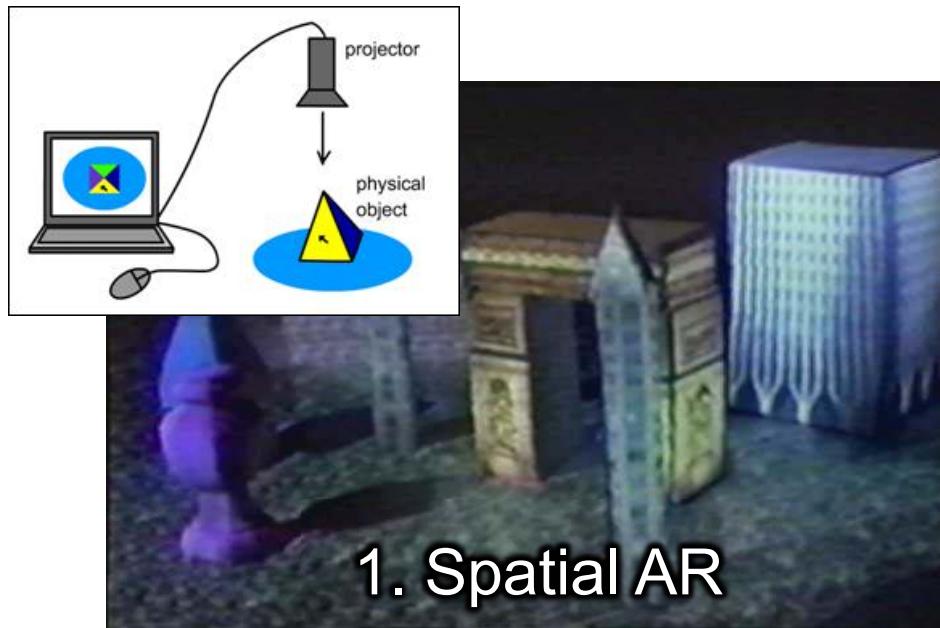
computer-generated image projected on real surfaces, so user needs not wear anything



No external devices in the physical environment but the user needs to wear/hold a display device

# Spatial AR

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computer-generated image  
projected on real surfaces, so  
user needs not wear anything



# Spatial AR Example

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# Spatial AR Example

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Advertisement... Make it appear to move!!!

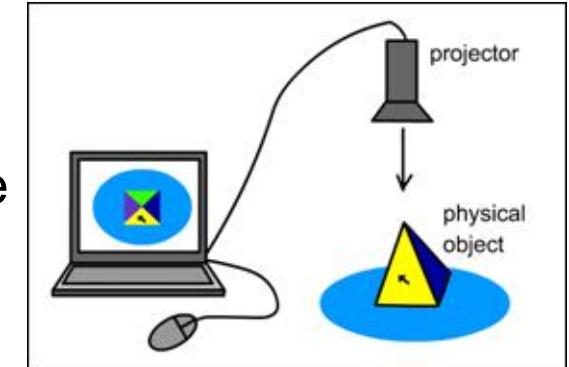


<https://www.youtube.com/watch?v=Ss70Zjuv5Rg>

# Spatial AR Example

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- Advantages:
  - No need for users to hold or wear any device
  - Simultaneously for a large number of audience
  - With good calibration, overlay can attach accurately on the physical contents (good spatial awareness)
- Disadvantages (or limitations):
  - Tedious setup and calibration
  - Limited interaction; occlusion between projector and surface
  - Night time or indoor environment
  - Usually need a high-power projector
  - Avoid surfaces that are black, reflective, and strong patterns



# See-through AR (handheld)

Case 1: Mobile-phone-based



Sketch AR (2020)  
<https://www.youtube.com/watch?v=asC0Gnh2P6s>



Augmented Reality in LEGO (2019)  
[https://www.youtube.com/watch?v=\\_RsNepC5GPU](https://www.youtube.com/watch?v=_RsNepC5GPU)



Amazon - Introducing AR view (2017)  
<https://www.amazon.com/adlp/arview>  
<https://www.youtube.com/watch?v=77ZJ3jw6EkA>

# See-through AR (handheld)

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- Advantages:
  - portable: mobile devices are easy to carry
  - easy to deploy: almost all cellphones and tablets have back cameras
  - good hardware and software support
  - compared to spatial AR, may use in bright environment
  - Inside-out: do not need external devices in the environment
- Disadvantages:
  - Unlike spatial AR, support mainly one or a few users simultaneously
  - Generally, we have to hold the device in front at all times
  - Overlay may disappear when device does not face the target region properly
  - Interaction is mainly screen-based rather than naturally in the physical world
  - Unlike spatial AR, tracking (due to changes in camera pose) is always a challenging problem

# See-through AR (glass-based)

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Case 2:

- Glass-based or visor-based
- Wearable



Apple Glasses (rumored for years)

<https://www.tomsguide.com/news/apple-glasses>



Microsoft's HoloLens 2

<https://www.microsoft.com/en-us/hololens>



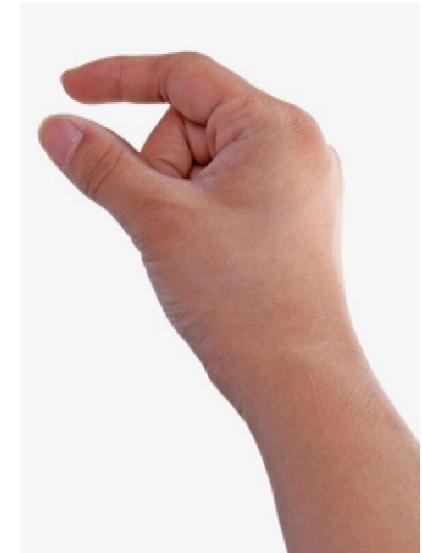
Magic Leap One

<https://www.youtube.com/watch?v=BRJigpPrAe4>

# See-through AR (glass-based)

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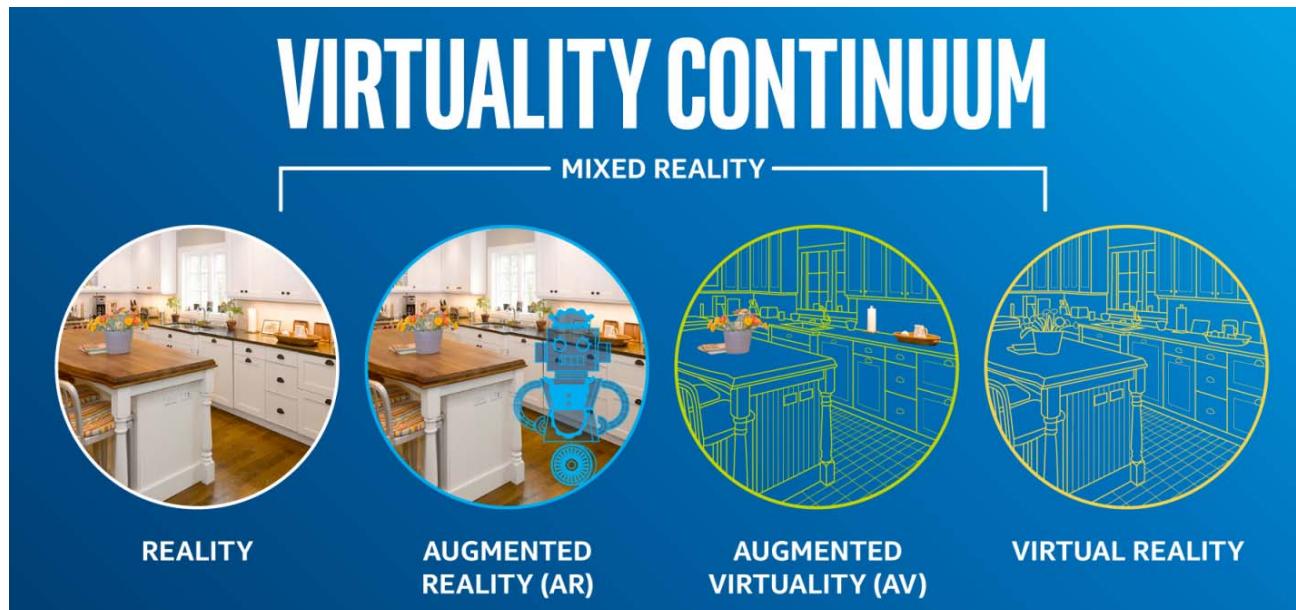
- Advantages:
  - Compared to handheld see-through AR, no need to hold a device
  - Existing devices such as HoloLens allows us to perform simple interactions such as the pinch gesture
- Disadvantages (for the existing devices):
  - The field-of-view (FOV) is still small (compared to human vision), where the virtual screen covers only a small region in user's view through the glass
  - Resolution of the virtual screen is low
  - The battery drain problem



Pinch  
gesture

# (3) To conclude...

- **Virtual reality (VR)** allows users to act as though they were somewhere else
- **Augmented reality (AR)** enhances our perception of the physical world with an overlay of information on the physical objects/environment
- **Mixed reality (MR)** shows combined real & virtual elements



**Extended Reality**  
or **Cross Reality (XR)**

- Take physical objects into digital worlds and/or take digital objects into the physical **reality**.

**Metaverse**: a network of 3D virtual worlds on social connection

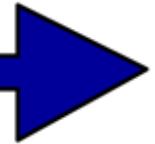
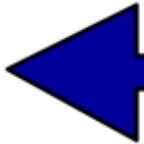
<https://en.wikipedia.org/wiki/Metaverse>

# VR <-> AR: Reality-virtuality continuum

REAL  
ENVIRONMENT

MIXED REALITY (MR)

VIRTUAL  
ENVIRONMENT

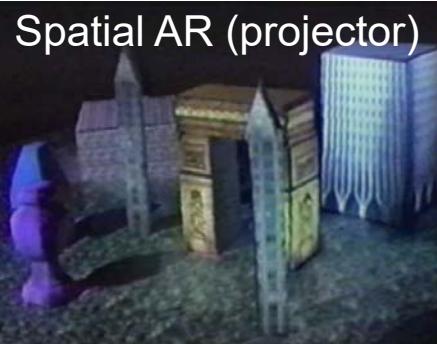


## Tangible User Interfaces (TUI)

A TUI uses real physical objects to both represent and interact with computer-generated information (Ishii & Ullmer, 2001).



## Spatial AR (projector)



## Augmented Reality (AR)

AR 'adds' computer-generated information to the real world (Azuma, et al. 2001).



## Augmented Virtuality (AV)

AV 'adds' real information to a computer-generated environment (Regenbrecht, et al. 2004).



## Virtual Reality (VR)

VR refers to completely computer-generated environments (Ni, Schmidt, Staadt, Livingston, Ball, & May, 2006; Burdea & Coffet 2003)



Or Augmented  
Virtual Reality



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## Topics:

- Introduction: interaction styles
- What is Direct Manipulation (DM)?
- Examples of DM
- Multitouch interactions
- Virtual and Augmented Reality (VR & AR)
- When AI meets VR & AR

# When AI meets VR & AR...

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- How AI contributes to AR?
  - AI can help to recognize and sense, including our hand and face, as well as the environment



AR Faces: accessories, makeup & BG



AR Tryout

# When AI meets VR & AR...

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- In VR, we can't see the real world, any problem?
- Visual disconnection from the reality

In a **survey of 108 current VR HMD users...**

We found that VR HMDs still have **significant usability issues** regarding **interacting with, and being aware of, reality.**

Two common problems:

- We cannot access the objects that we want to access
- We can easily run into objects that we do not want to

# When AI meets VR & AR...

- Can AI sense the physical environment around us and identify the necessary information?



Depth camera to sense the environment

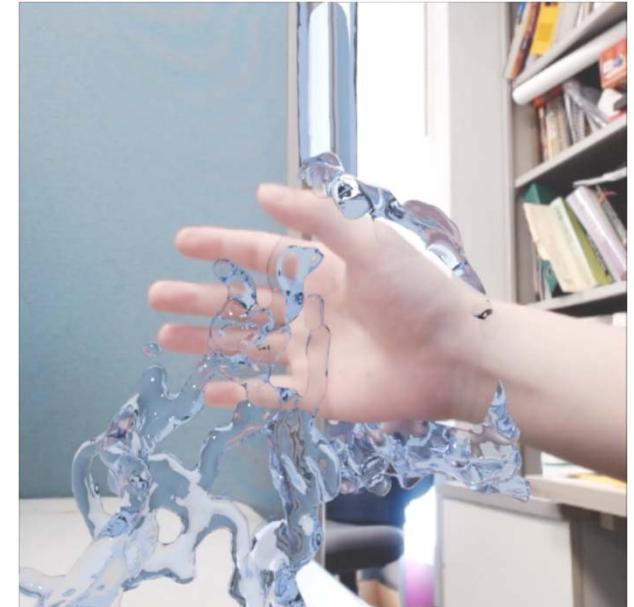
<https://dl.acm.org/doi/10.1145/2702123.2702382>



# When AI meets VR & AR...

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- With AI, can we better interact with AR objects?



New results from my recent research work after ICCV2021:

<https://wbstx.github.io/handar/>

# Summary

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- Direct Manipulation
  - Today is common-place
  - OAI vs AOI model
  - From WIMP to direct manipulation
  - Three principles
  - Pros & Cons
    - Requires more screen space
    - Requires comprehensible design
    - Requires more development work
    - For many tasks, keystrokes could be faster
- Extensions and emerging areas
  - Multitouch: generalization of touchscreen, implementation approaches, gestures, and issues
  - VR & AR: Reality -> AR -> Augmented Virtuality -> VR, VR environments, and spatial AR vs see-through AR
  - AI and its applications to VR & AR

# References

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- When AI meets AR  
<https://blog.adobe.com/en/publish/2018/12/18/ai-meets-ar.html>
- Textbook by Ben Shneiderman
- “Direct Manipulation: Definition”  
by S. SHERUGAR and R. BUDIU on Aug. 21, 2016:  
<https://www.nngroup.com/articles/direct-manipulation/>