Lecture 2

Gestural Interaction

Baptiste Caramiaux

Admin

Course structure:

- Fridays 1:30pm - 4:30pm
- “Exam”: February 2nd, 2018

Online ressources:

- https://github.com/bcaramiaux/GMI
- Slides, bibliography, code

Main contact: baptiste.caramiaux@ircam.fr

Outline

1. Brief history and examples
2. Gesture: definitions, functions
3. Gestures in interaction
4. Designing gestural interactions

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1. **Brief history and examples**
2. Gesture: definitions, functions
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Brief history

Command Line Interface

Codified, Strict

CLI

60’s

Brief history

Command Line Interface

Codified, Strict

Graphical User Interface

Metaphor, exploratory

CLI

GUI

60’s

80’s

Brief history

Command Line Interface

Codified, Strict

CLI

60’s

Graphical User Interface

Metaphor, exploratory

GUI

80’s

Natural User Interface

Direct, intuitive

NUI

00’s

“Natural” interaction

Natural interaction is usually used for invisible interfaces, independently of the level of expertise (Terminology not widely accepted)

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Gesture can be seen as a “natural” medium for interaction

Background in cognitive science

Embodied cognition

- “Cognition is embodied when it is deeply dependent upon features of the physical body of an agent, that is, when aspects of the agent's body beyond the brain play a significant causal or physically constitutive role in cognitive processing.”

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Examples motivating embodied cognition:

- Gesturing when we speak (McNeill 1992)
- Vision is often action-guiding (O'Regan and Noë 2001)
- Mirror neurons (Rizzolatti and Craighero 2004)

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Examples motivating embodied cognition:

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See: entry “Embodied Cognition” from the Stanford Encyclopedia of Philosophy (https://plato.stanford.edu/entries/embodied-cognition/)

Applications

Gestural interaction with mobile systems

Somehow more “natural” than writing text

(NB: first iPhone released in 2007)

Applications

Shape Writer

“Quick”

Kristensson, P.O. and Zhai, S. SHARK²: A Large Vocabulary Shorthand Writing System for Pen-Based Computers. *UIST’04*

Applications

Video games

Applications

Parallel evolution

CLI

GUI

NUI

60’s 80’s 00’s

Science Fiction

Outline

1. Brief history and examples
2. **Gesture: definitions, functions**
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Defining gesture

?

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HCI: A **gesture** is a **movement** of the body that contains information (Kurtenbach & Hulteen, 1990)

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=> **What** it is performed

Defining gesture

Non-Verbal Communication: “Gesture [...] is a label for **actions** that have the features of manifest **deliberate expressiveness**” (Kendon, 2004)

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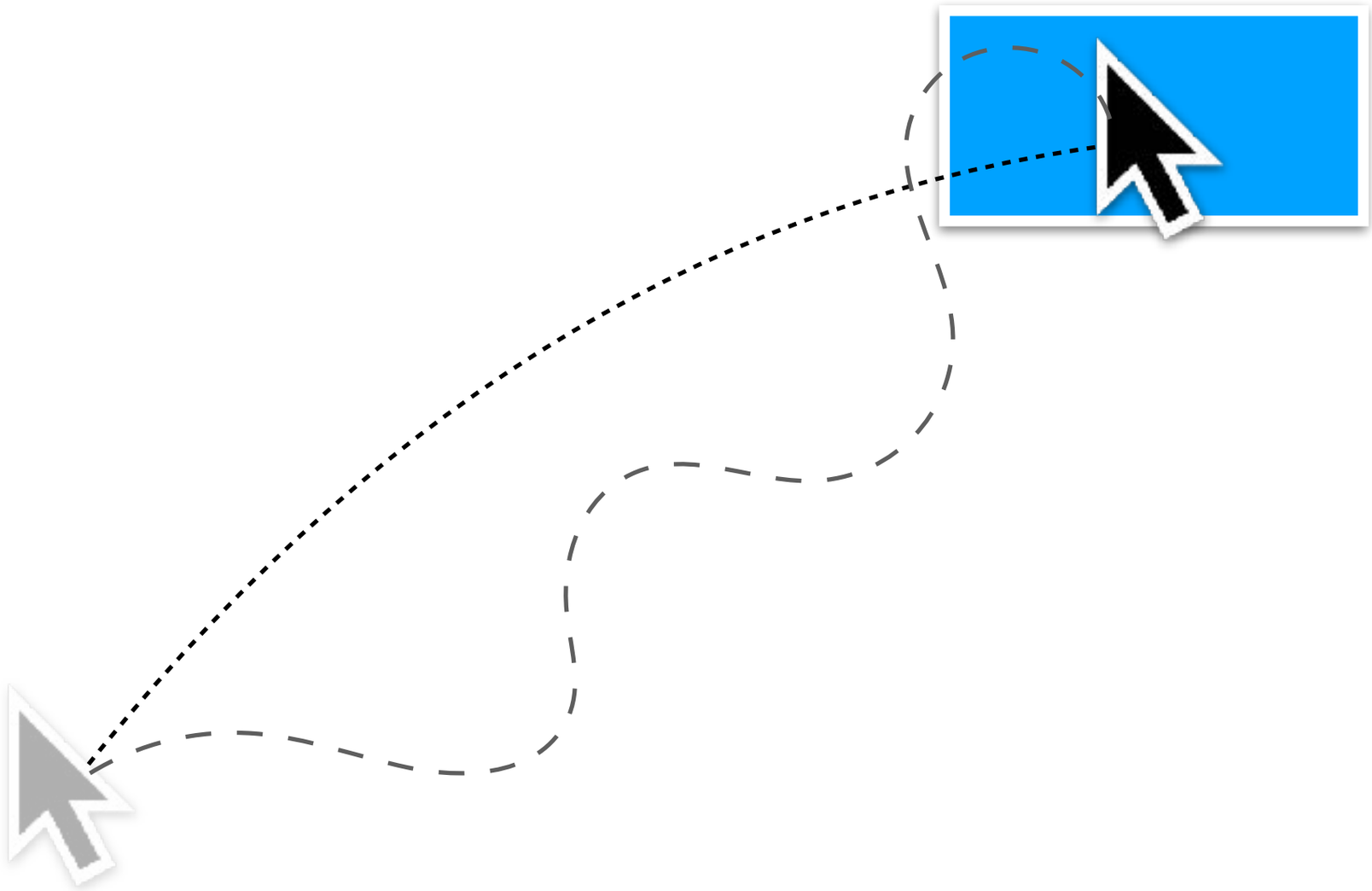
=> **What** and **How** it is performed

Is pointing a gesture?



Functions

Semiotic gestures

- To communicate meaningful information

Ergotic gestures

- To manipulate the physical world and create artefacts

Epistemic gestures

- To learn from the environment through tactile experience and haptic exploration

(Cadoz, C. Le geste, canal de communication homme/machine: la communication “instrumentale”. techniques et sciences informatiques. Vol 13 - n01/1994, pages 31 à 61.

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Ergodic gestures

To **manipulate** the physical world and create artefacts

Epistemic gestures

To **learn** from the environment through tactile experience and haptic exploration

Synthesis

Aspects of a gesture

- can be static (= **posture**) or dynamic
- is defined in time
- is linked to a transfer of information (e.g. ergotic, epistemic)
- is deliberate
- conveys expression

Exercice

From Gestural Interaction you know, find examples of

- Semiotic
- Ergotic
- Epistemic

Which one is the most used?

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Why using gestures in UI?

...

Why using gestures in UI?

Based on user's existing drawing and handwriting **skills**

Physically **chunk a command** and its operands into a single action

Implicit and fast **mode switching**

Eyes-free interaction

Alternative to buttons for small displays

Fun

Distant interaction

…

Why using gestures in UI?

Drawing skills

Thorne, M., Burke, D. van de Panne, M. Motion doodles: an interface for sketching character motion. *SIGGRAPH'07*

Why using gestures in UI?

Fun!

Muller et al. Looking Glass: A Field Study on Noticing Interactivity of a Shop Window. *CHI'12*

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Discrete outputs

Discrete means separated and divided elements in a set.
Example: letters are discrete elements of an alphabet.

Gesture to command :

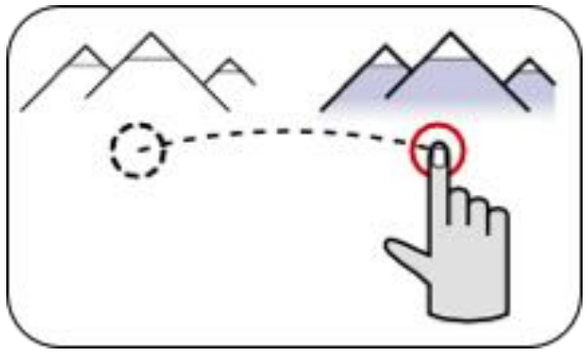
Gesture to symbol:

- Gesture to textual symbols

Continuous outputs

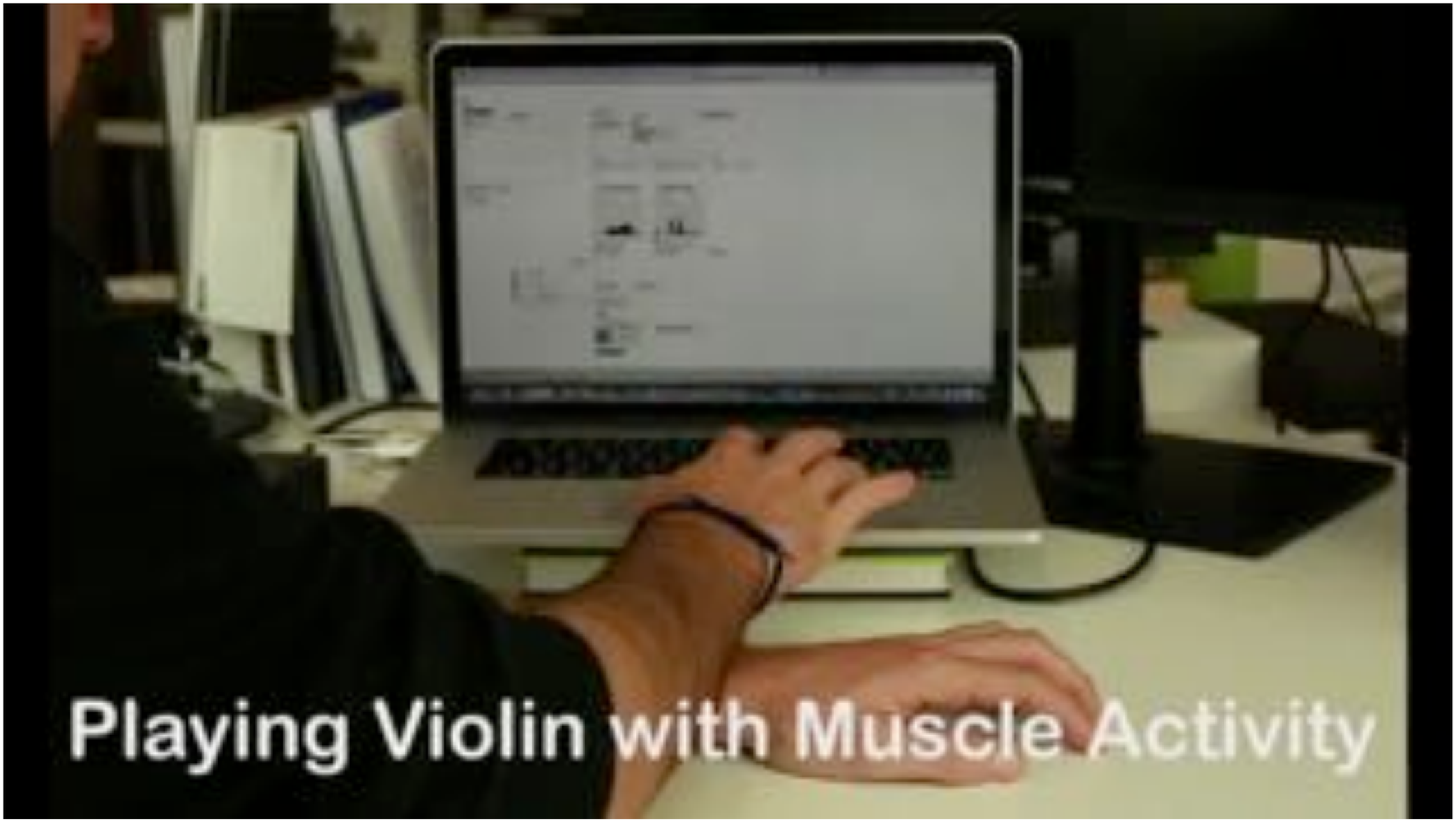
Gesture to range of values:

- Uni-dimensional “Sliders”
- Bi-dimensional pads
- High-dimensional



Myo by Thalmic

"Musical" example

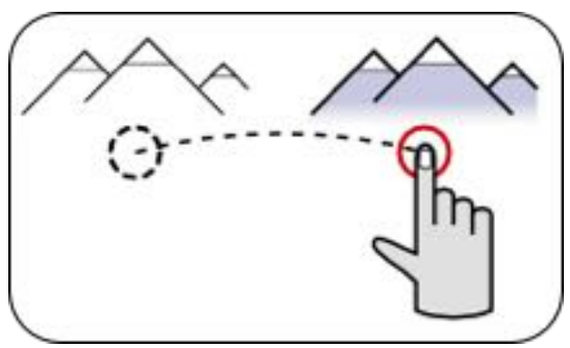


(Caramiaux, Donnarumma, Tanaka. Understanding Gesture Expressivity through Muscle Sensing, *ACM ToCHI 2015*)

Analog vs. abstract gestures

Analog gestures

- Mimic the physical or conventional effects of the world
- Direct manipulation
- Easier to learn
- Example : slide gesture can cause a document to pan



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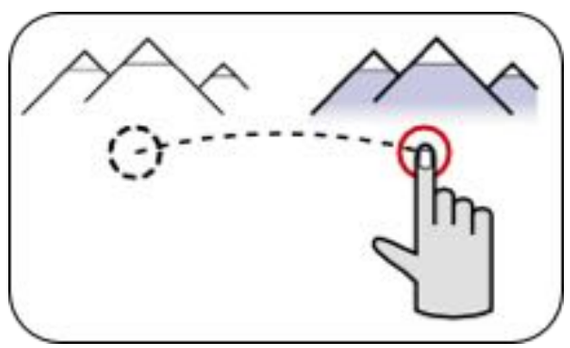

Abstract gestures

- Arbitrary
- Example: draw X to close a document

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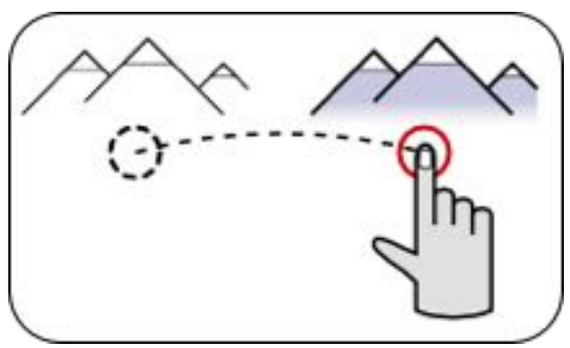


Abstract gestures

- Arbitrary
- Example: draw X to close a document

Analog-Abstract classification

- Is a spectrum (not a dichotomy)
- Resemble physical effects to a degree

Processing: post hoc vs. realtime

Post hoc

- Recognizing a gesture after it has been completely drawn

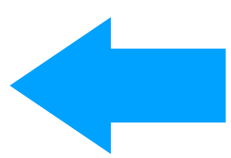
Realtime

- Recognising a gesture as it is drawn
- Requires feedback

Temporality: post hoc, realtime

Post hoc

- Recognizing a gesture after it has been completely drawn



Commonly used strategy

Realtime

- Recognising a gesture as it is drawn
- Requires feedback

Temporality: post hoc, realtime

Post hoc

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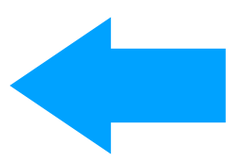

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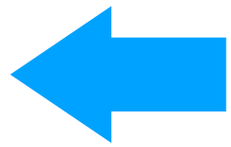


More powerful, more challenging!

‘post-hoc’ example: $1 recogniser

http://depts.washington.edu/madlab/proj/dollar/index.html

Wobbrock, J. O., Wilson, A. D., & Li, Y. Gestures without libraries, toolkits or training: a $1 recognizer for user interface prototypes. *UIST’07*

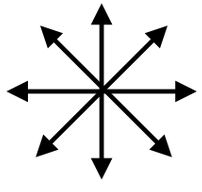
‘realtime’ example: GVF

Caramiaux, B., Montecchio, N., Tanaka, A., & Bevilacqua, F. Adaptive gesture recognition with variation estimation for interactive systems. *ACM TiiS 2015*

Complexity

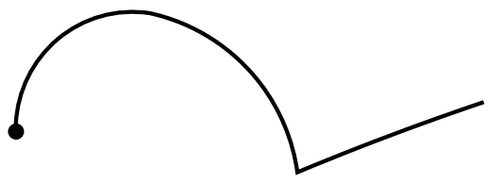
Zero order

- Touch points (soft button tap)
- orientation, finger id, pression



First order

- Stroke gestures



Higher order

- Multi-stroke gesture
- multi-touch gesture (multiple fingers or multiple hands)

Complexity is related to the difficulty to memorise and perform (**cognitive** and **motor** constraints, see Lecture 3)

Relationship with the device

On the device

with the device

around the device

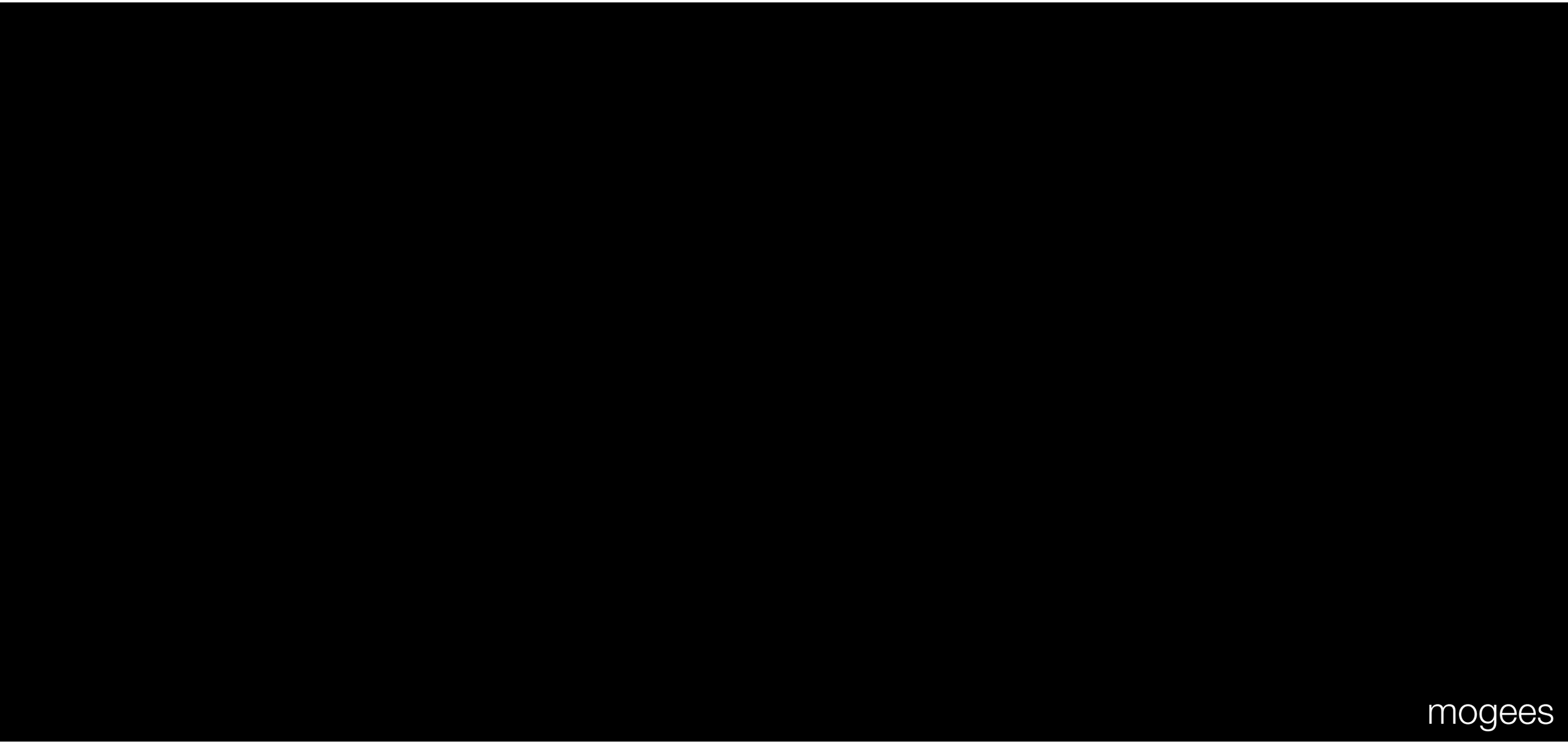
far from the device

On the device

On the device - music

Reactable

On the "device" (object augmentation)



On the device - Modalities

Finger

- pressure
- finger id
- orientation of finger

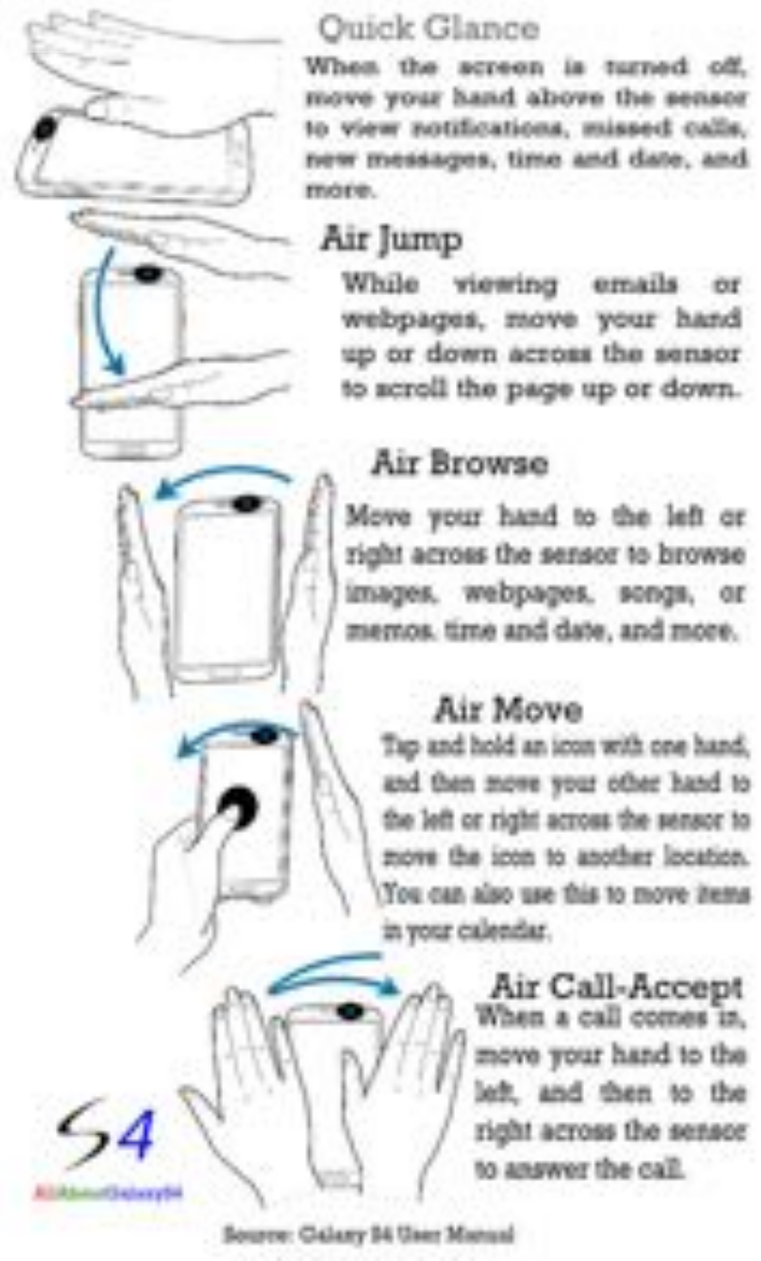
Multi-touch

- Object
- Number of fingers body part

Pen vs. touch objects

With the device


Around the device


Quick Glance
When the screen is turned off, move your hand above the sensor to view notifications, missed calls, new messages, time and date, and more.
Air Jump
While viewing emails or webpages, move your hand up or down across the sensor to scroll the page up or down.
Air Browse
Move your hand to the left or right across the sensor to browse images, webpages, songs, or memos. time and date, and more.
Air Move
Tap and hold an icon with one hand, and then move your other hand to the left or right across the sensor to move the icon to another location. You can also use this to move items in your calendar.
Air Call-Accept
When a call comes in, move your hand to the left, and then to the right across the sensor to answer the call.
S4
Source: Galaxy S4 User Manual

Around the device

Abracadabra: Wireless, High-Precision, and Unpowered Finger Input for Very Small Mobile Devices

Chris Harrison
chris.harrison@cs.cmu.edu

Scott Hudson
scott.hudson@cs.cmu.edu

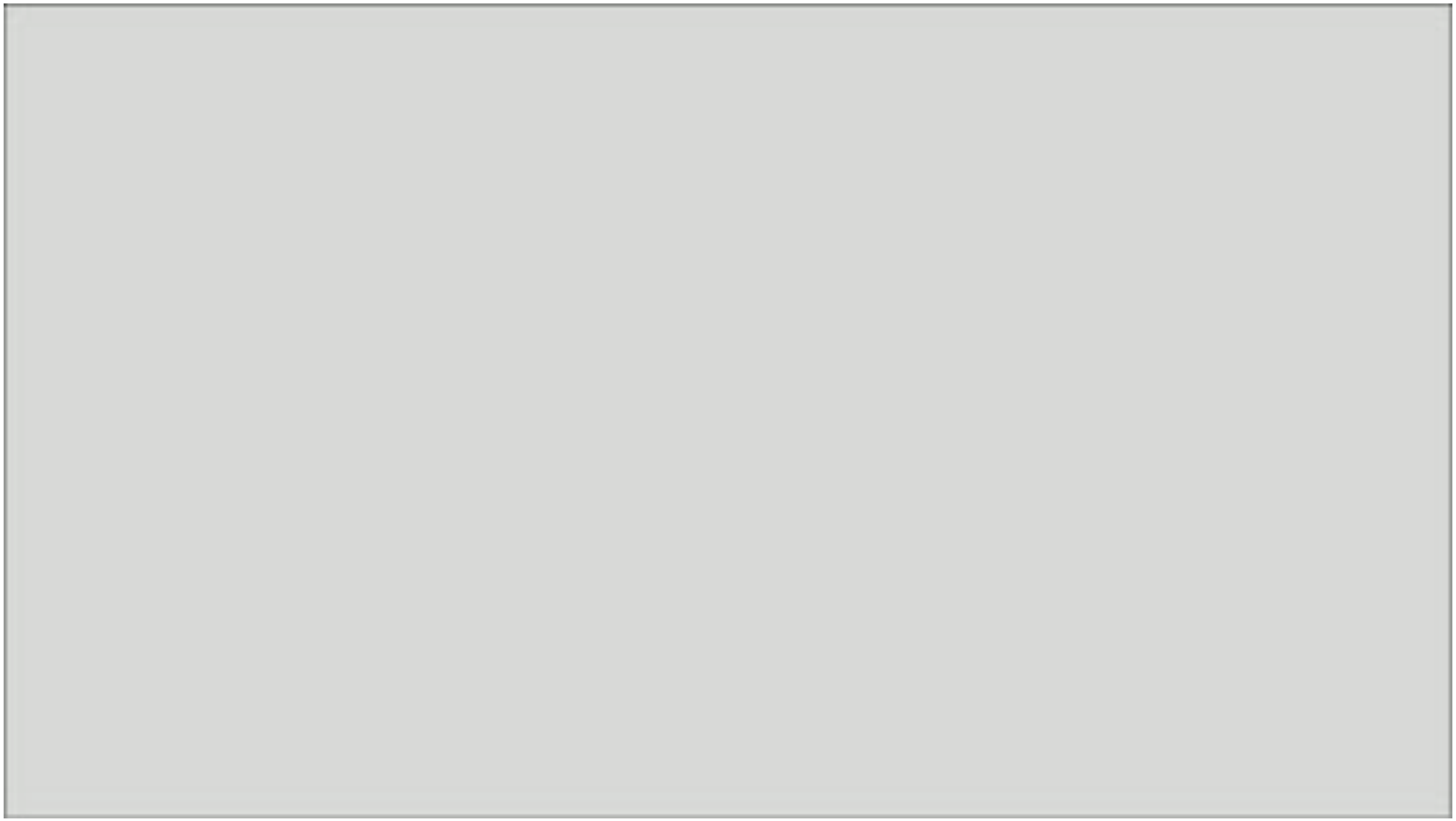
Human-Computer Interaction Institute

Carnegie Mellon

Far from the device

Game (Kinect)

Far from the device



LeapMotion

Synthesis

Gestures can be “mapped” to discrete and/or continuous outputs

Gestures can be analog or abstract

- Depending on the extent to which they mimic the physical or conventional aspect of the world

Gestures can be processed (typically recognized) after execution or during execution

Complexity of gestures has several orders and involves expertise

Gesture can relate with the device according to four different ways

- On, with, around, or far

Outline

1. Brief history and examples
2. Gesture: definitions, functions
3. Gestures in interaction
4. **Designing gestural interactions**

Designing gestural interactions

Imagine you are a **designer**

You have a list of **24 commands** …

…and you want (have) to build a **gestural interface**

What do you have to do?

Steps

Create a **gesture set**

Define a gesture-command **mapping**

Build a gesture **recognizer**

Provide a **teaching** method

Evaluate your design

Steps

Designing gestural interactions

1. Create a **gesture set**
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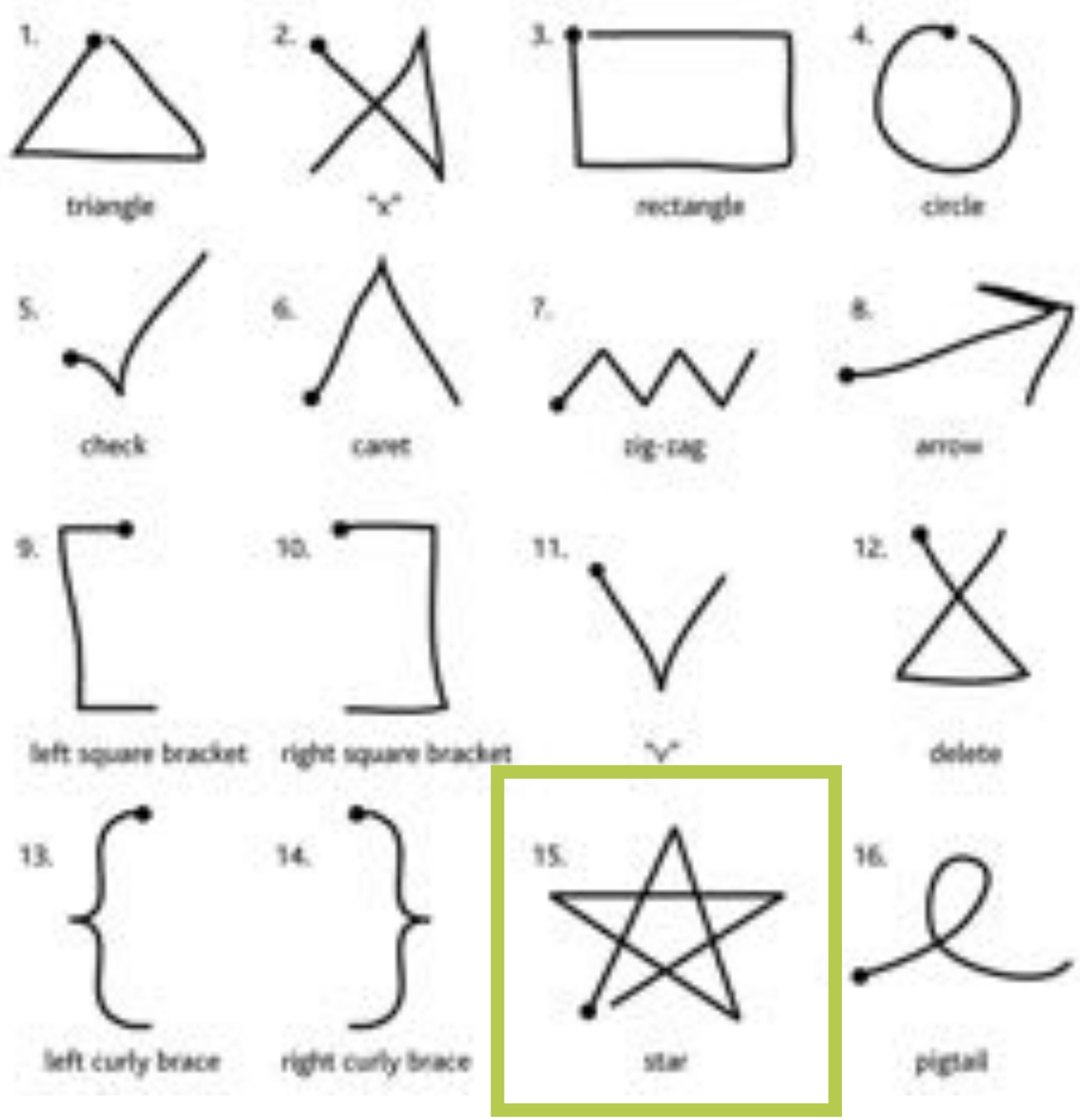
5. **Evaluate** your design

Create a gesture set

No Grammar

Gestures as symbols



Create a gesture set

Grammar

Hierarchy, articulatory meaning

Orientation + Curvature

Steps

Designing gestural interactions

1. ~~Create a **gesture set**~~
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User-centred approach

Goal

- Capture “natural” mappings

User-centred approach

Goal

- Capture “natural” mappings

Procedure:

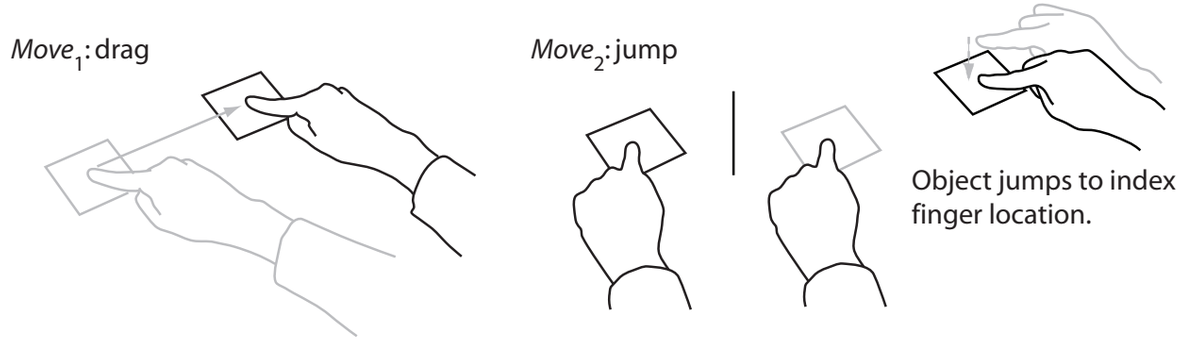
- Several users
- The experimenter shows the effect
- Users have to guess the gesture
- For each command, keep the most frequent gesture

User-centred approach

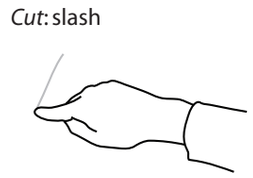
Examples on a touch surface

- Select

- Move



- Cut



(Wilson et al. User-Defined Gestures for Surface Computing. *CHI'2009*)

Is it a good technique?

Advantage: used expectation from users (“natural” mappings)

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Problem: does work for a tiny set of gestures

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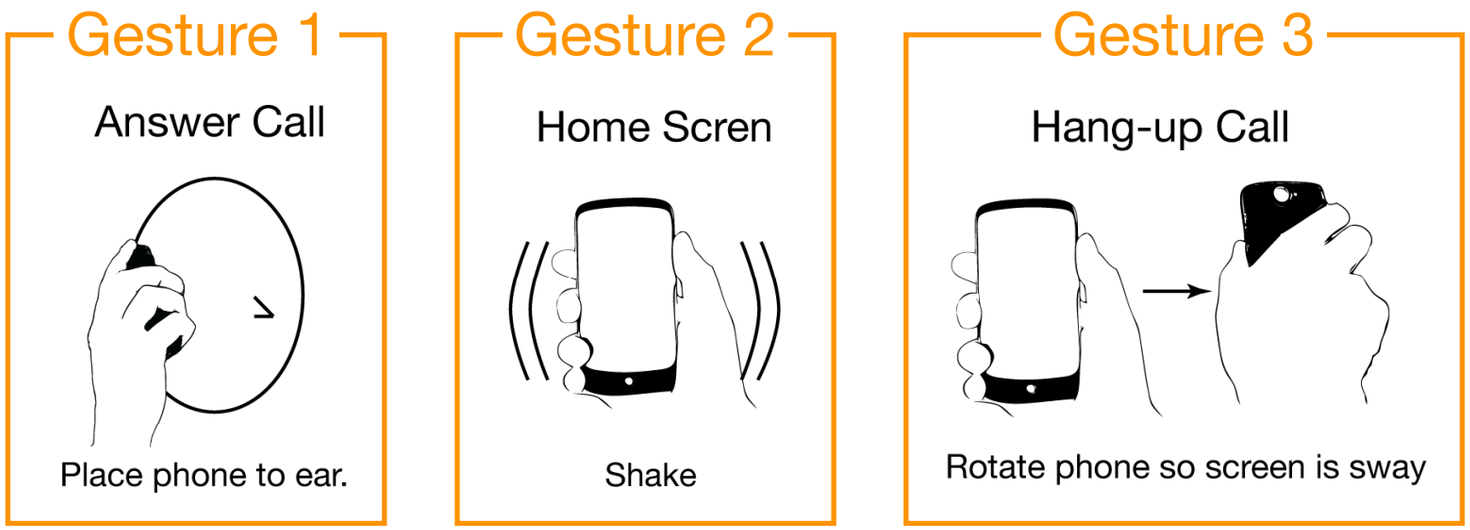
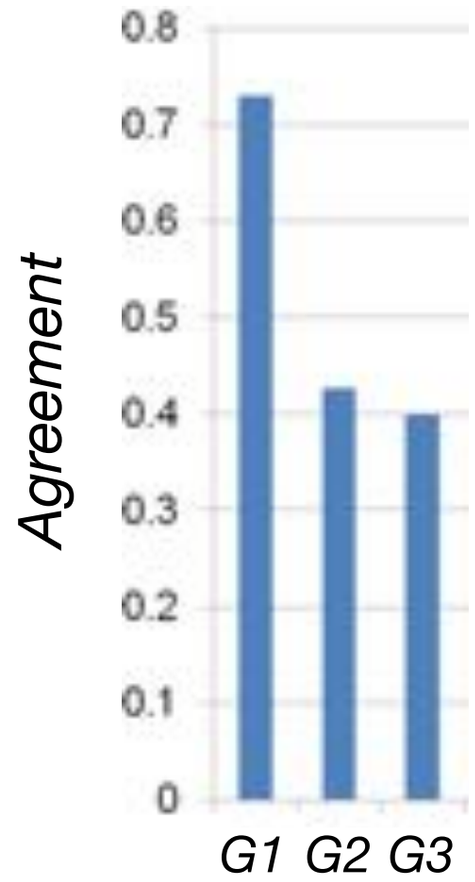
Example with mobile interaction





(Ruiz et al. User-Defined Motion Gestures for Mobile Interaction. CHI’2011)

Questioning the mapping

If no agreement, is gestural interaction needed at all?

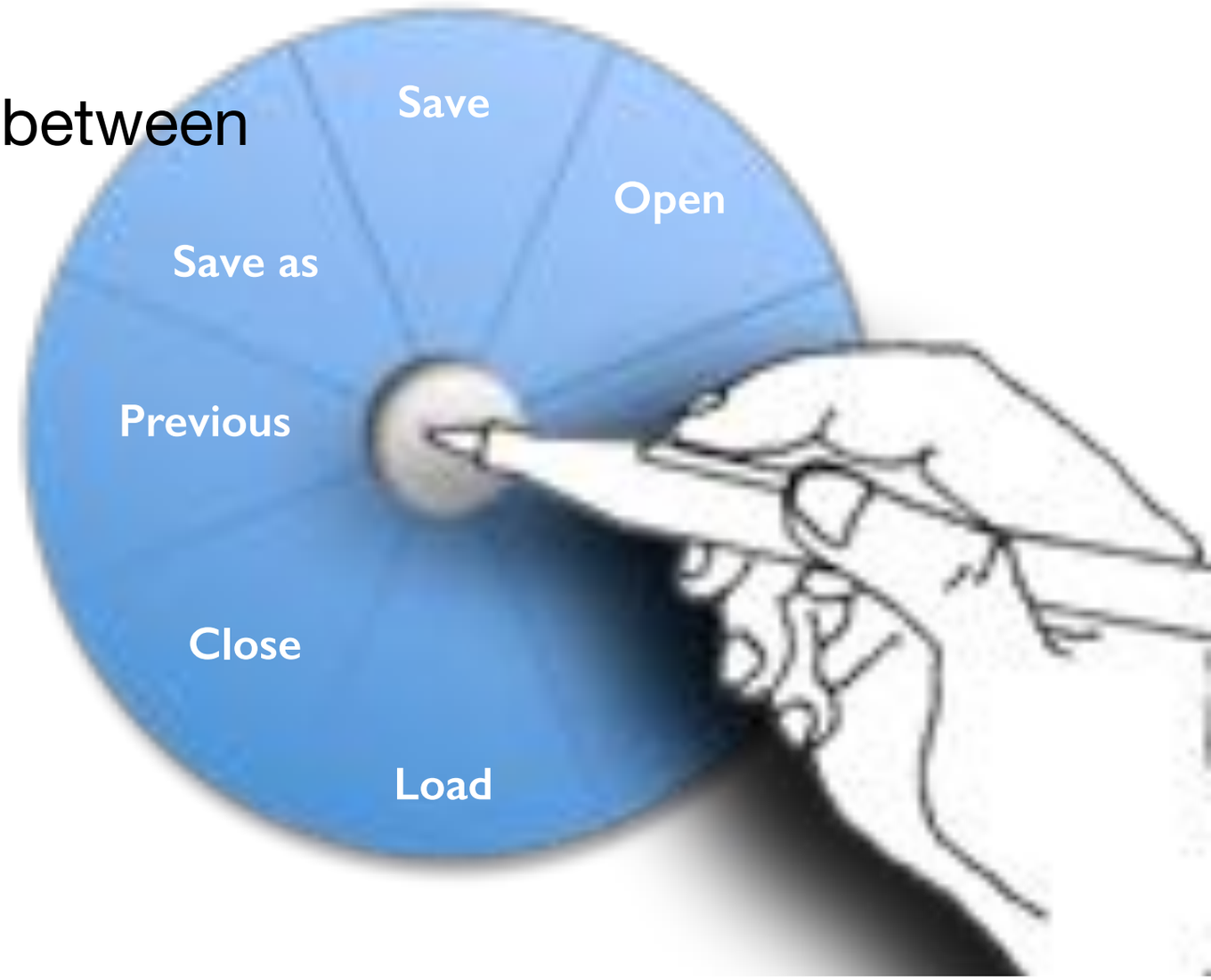
Other approaches

Semantic relationships

- Focus on the relationship between gestures and commands

Highlight:

- Similarity
- Opposition
- Etc



Steps

Designing gestural interactions

1. ~~Create a **gesture set**~~
2. ~~Define a gesture-command **mapping**~~
3. Build a gesture **recognizer**
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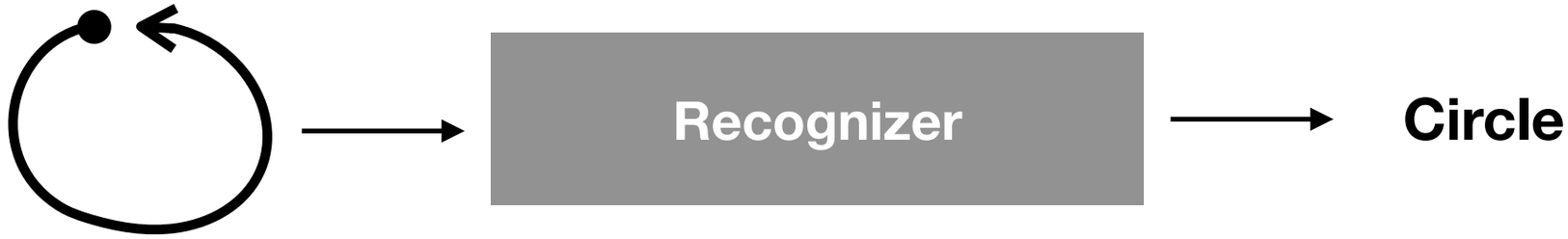
Gesture recognition

A gesture **recognizer** is a system able to take an **unknown input gesture** and **classify** it as being one element of a predefined **set of gestures** (**vocabulary**).

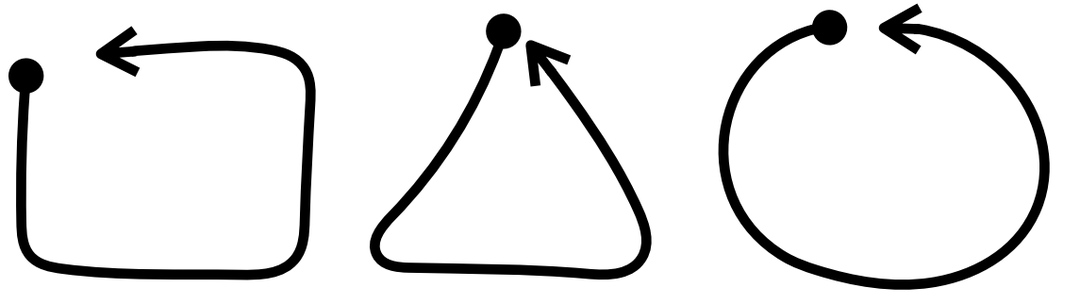


Two important strategies

- Template-based approach
- Training-based approach

Template-based

Record a set of gestures (**vocabulary**) and assign a label to each gesture



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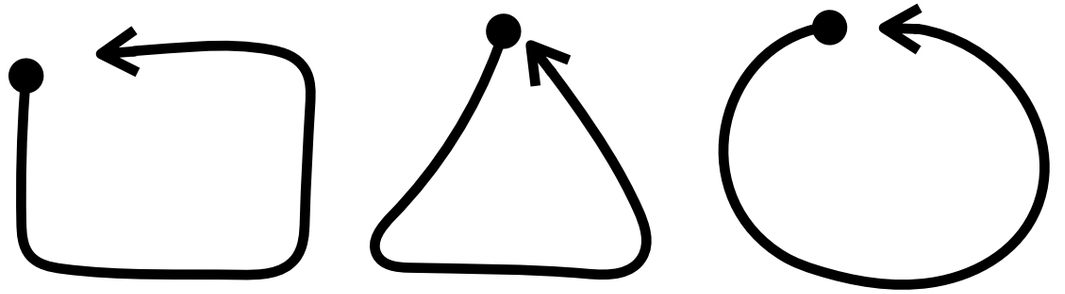
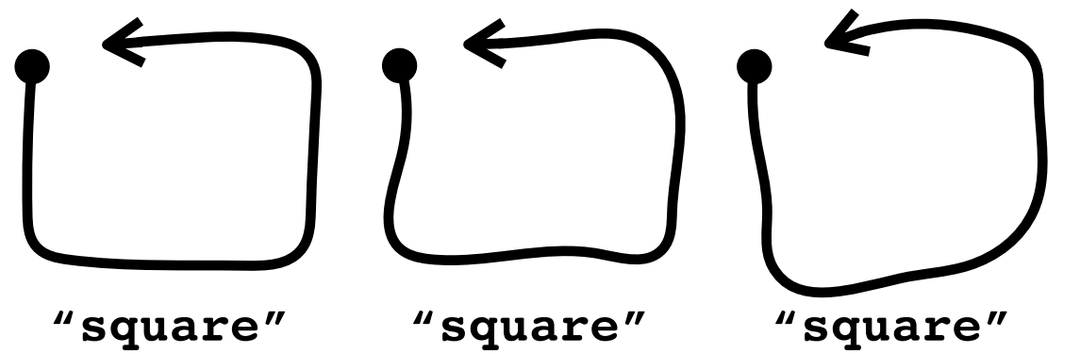


Each recorded gesture can be recorded once or multiple times (with the **same label**)



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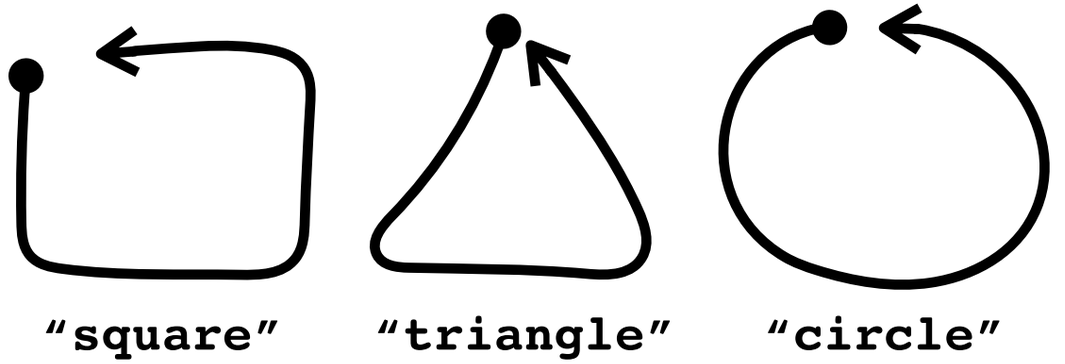

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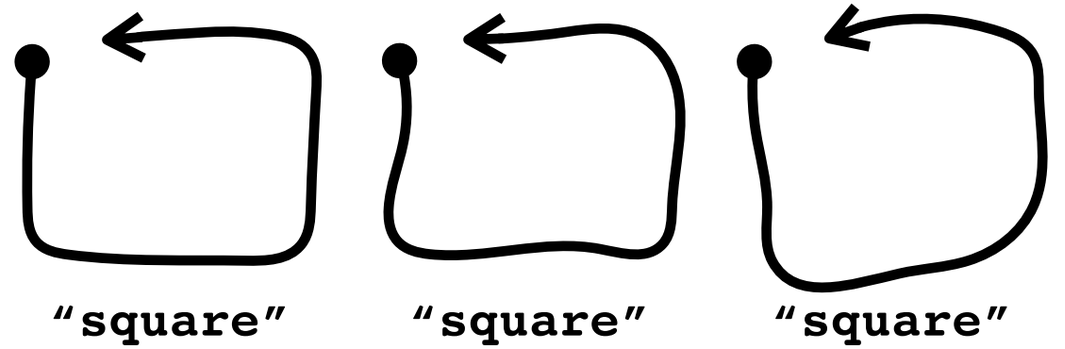
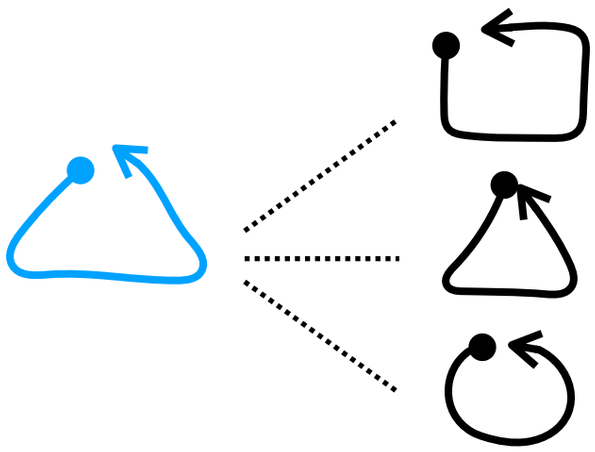


For an input unknown gesture, compute distance between the input gesture and the pre-recorded gestures



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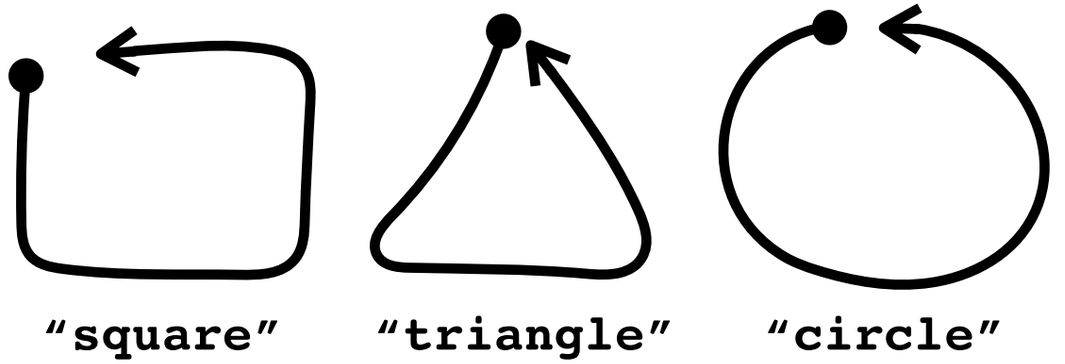

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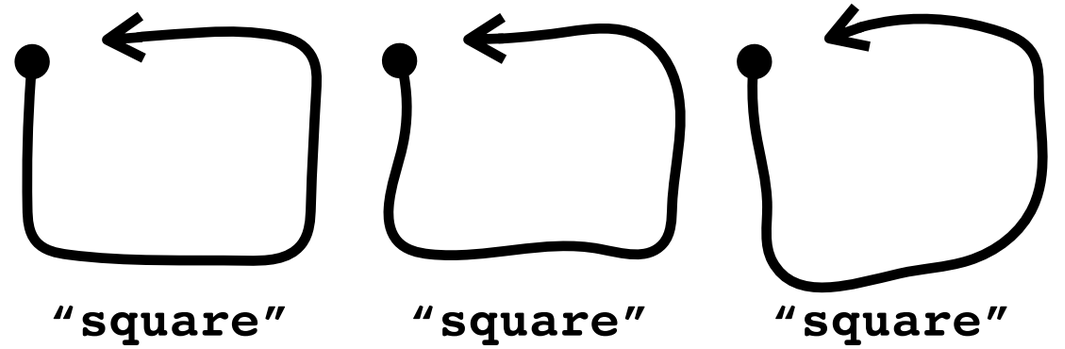

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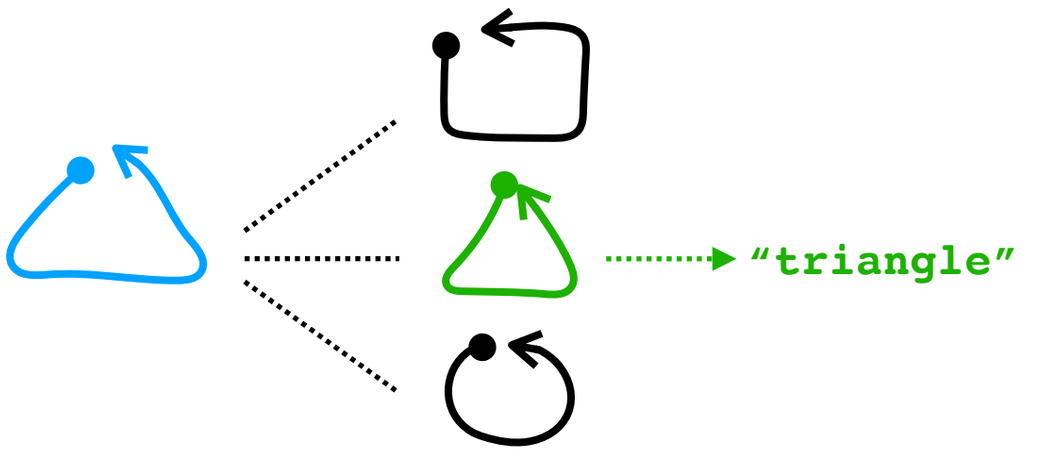


Return gesture label w.r.t smallest distance value

Examples

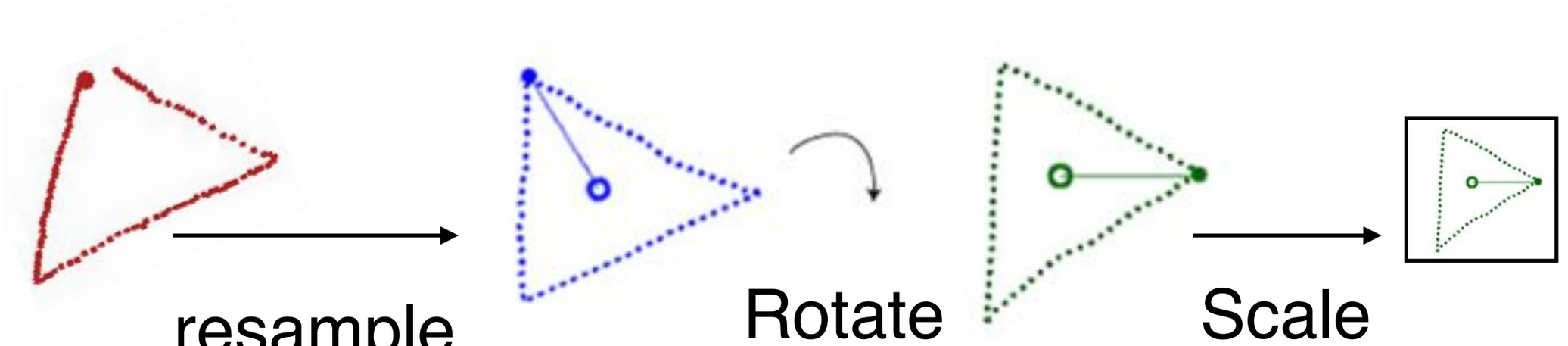
HCI literature

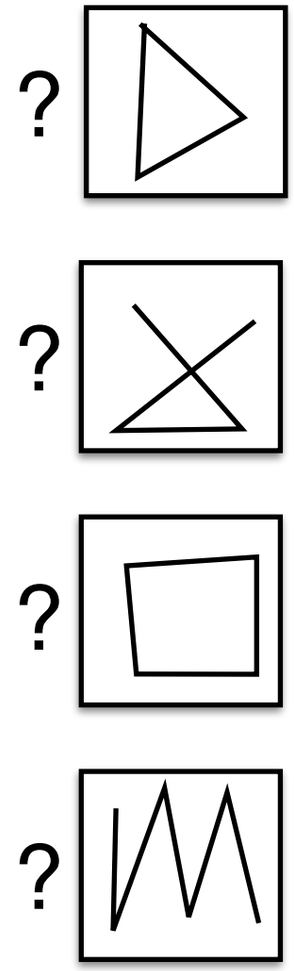
- Rubine (Rubine, 1991)
- $1 recognizer (Wobbrock et al. 2007)

Machine-learning literature

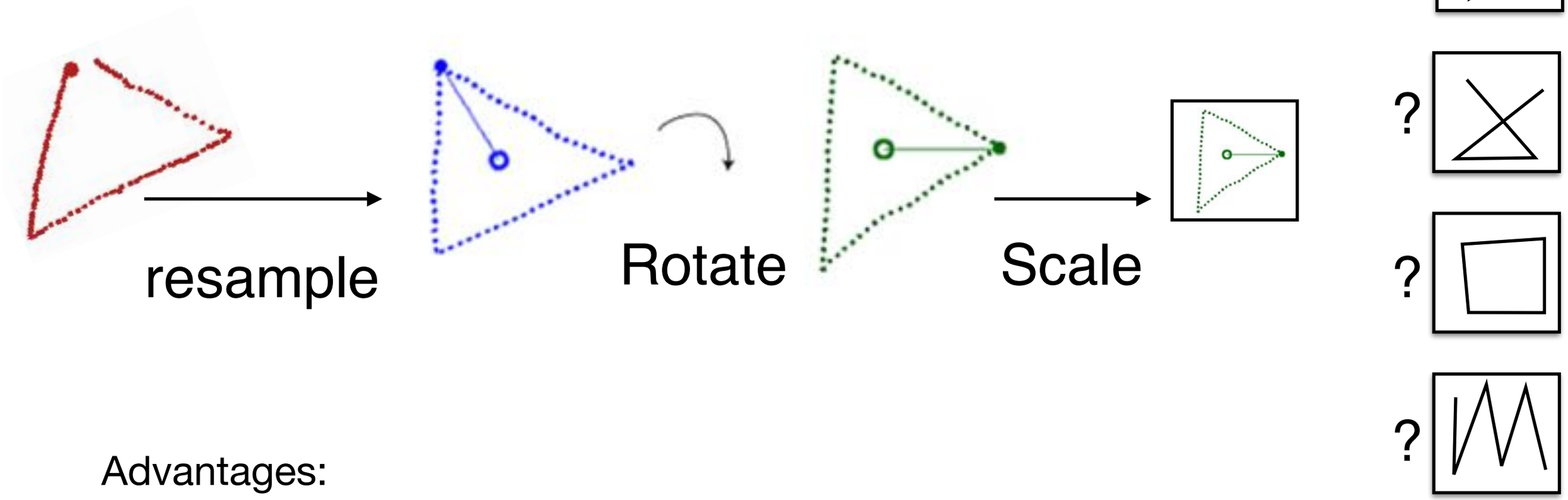
- k-Nearest Neighbor
- Dynamic Time Warping for classification

$1 recognizer





$1 recognizer



Advantages:

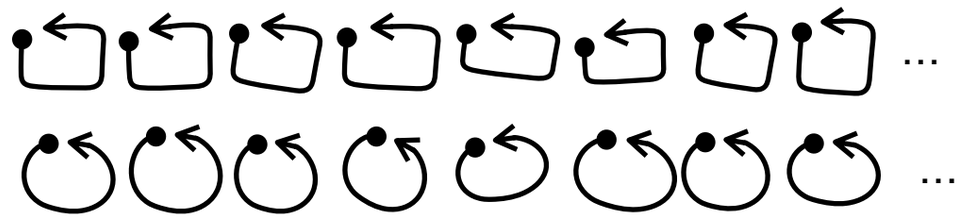
- Technically: Invariants to change of dynamics, scale and orientation
- HCI: enable novice programmers to incorporate gestures into their UI prototypes

Training-based approach

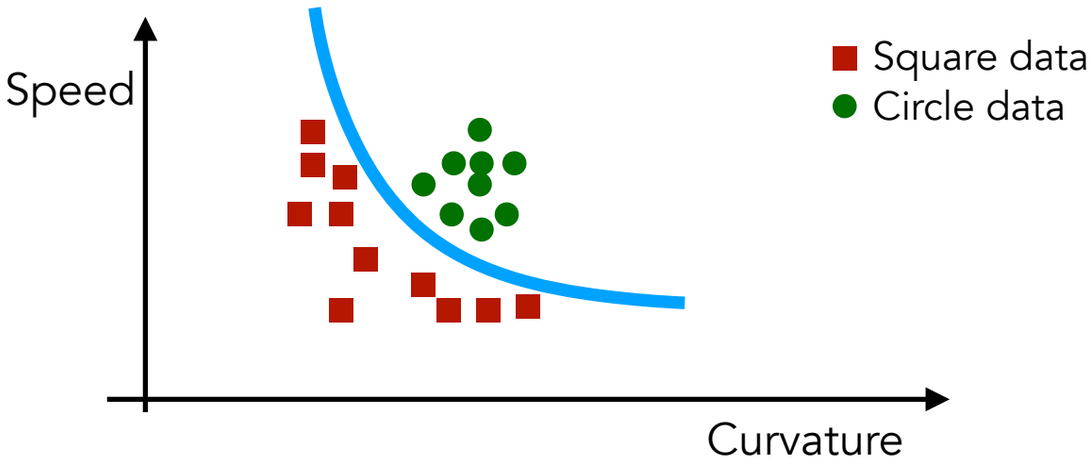
Record **several** examples of a set of gestures and assign a label to each gesture

“square”

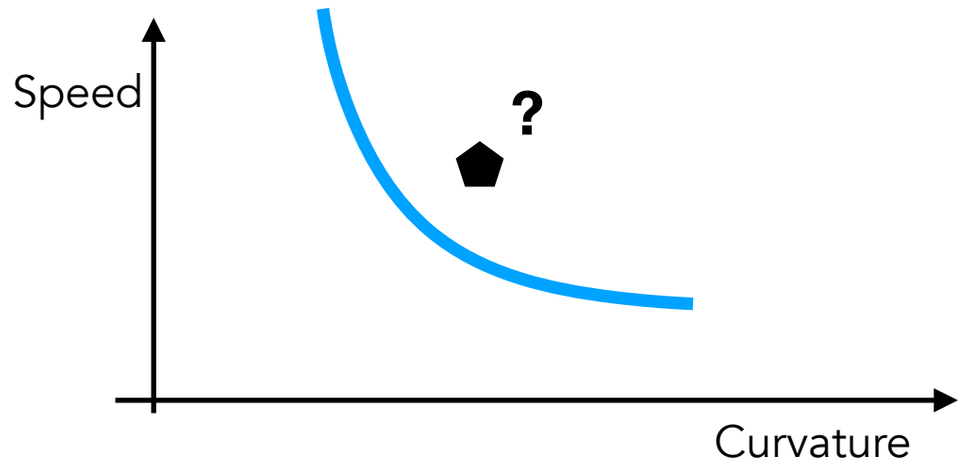
“circle”



Build a **model** allowing for discriminating “square” data from “circle” data



For an unknown gesture, take decision based on the model



Examples

Mostly used in the HCI literature

- Support Vector Machine (SVM)
- Naive Bayes (NB)
- Gaussian Mixture Model(GMM) for classification
- Hidden Markov Model (HMM), for temporal sequences

More

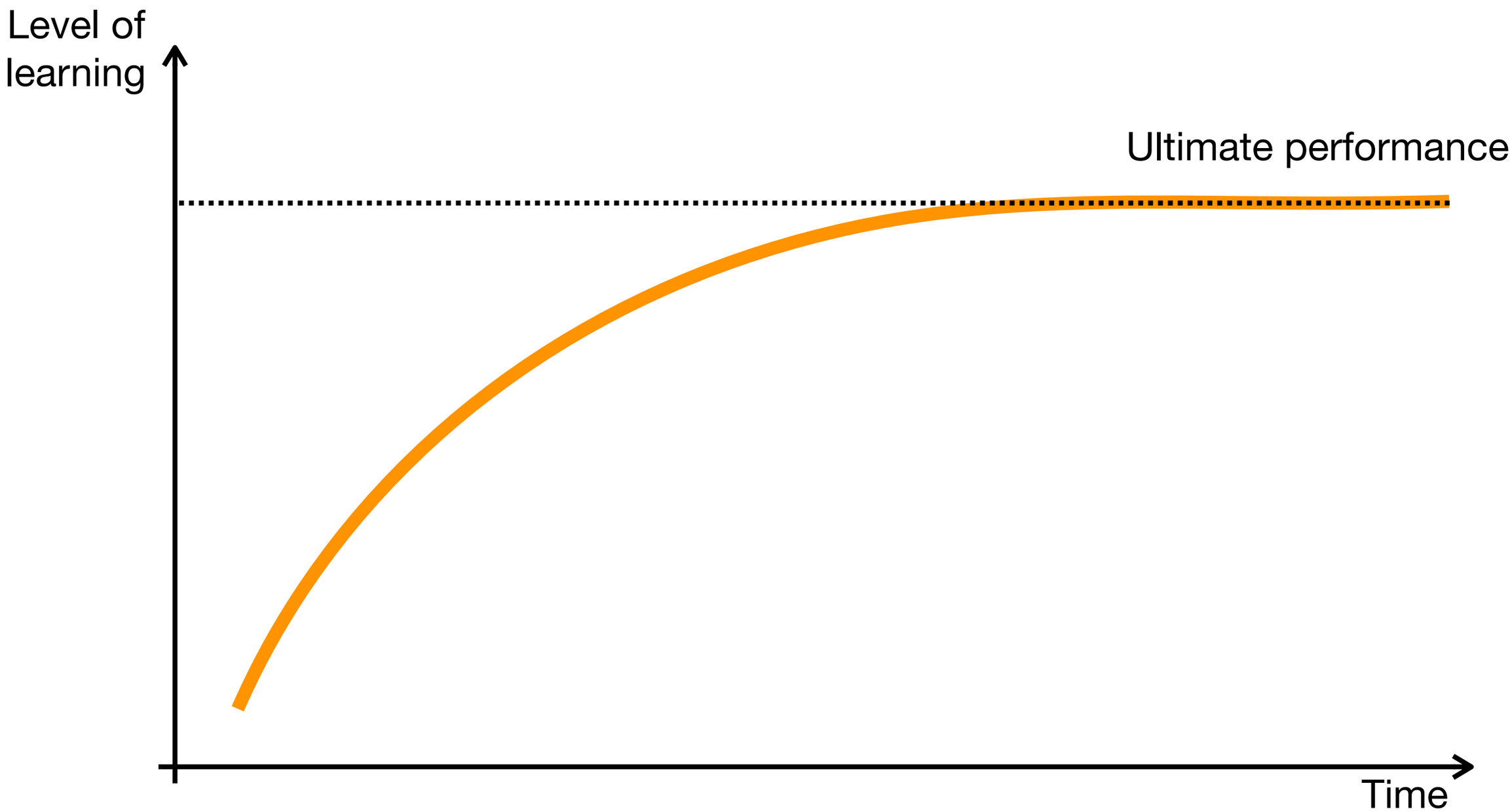
Cf. Lecture on “Gesture Recognition and Machine Learning”

Steps

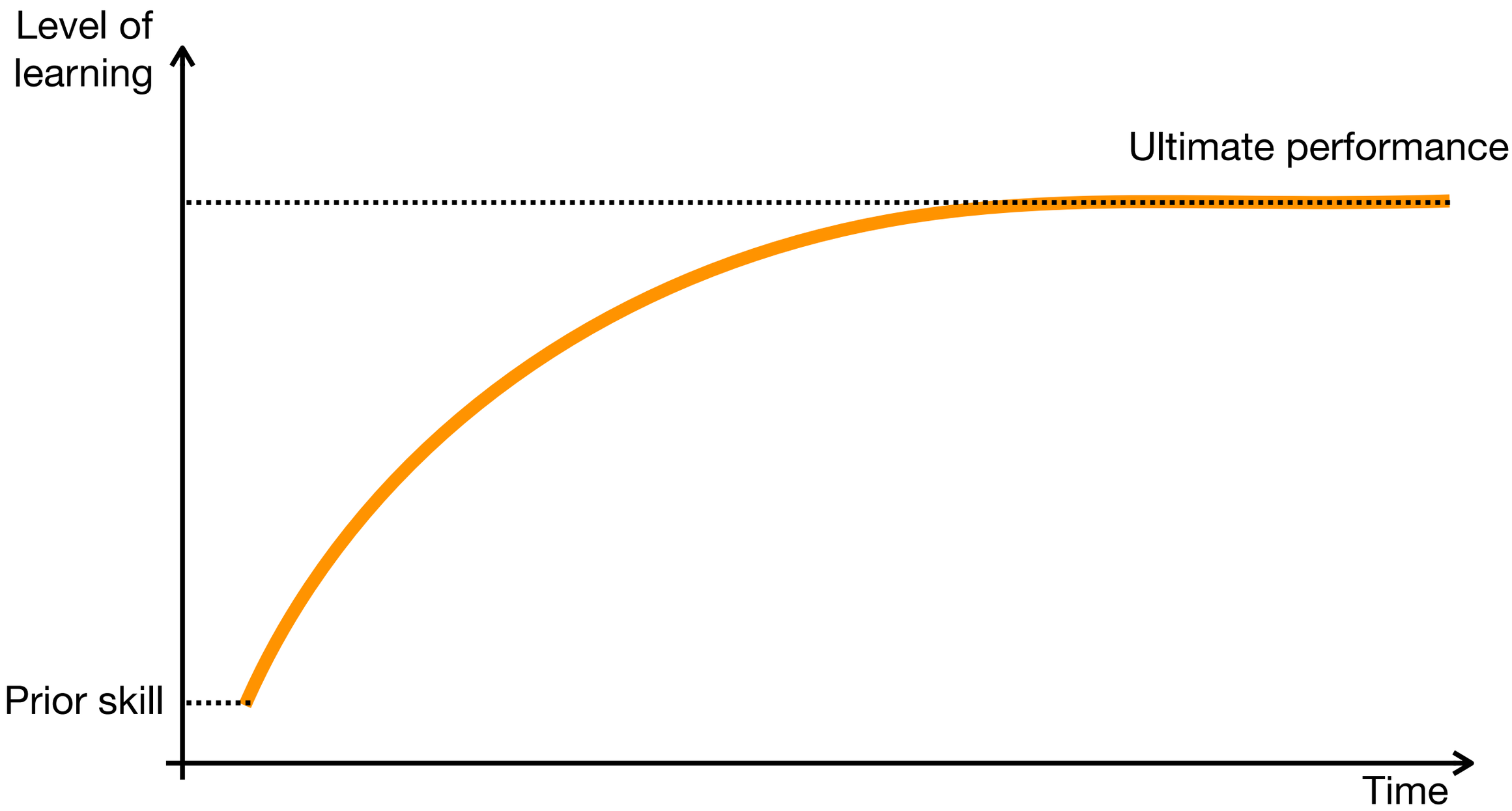
Designing gestural interactions

1. ~~Create a **gesture set**~~
2. ~~Define a gesture-command **mapping**~~
3. ~~Build a gesture **recognizer**~~
4. Provide a **teaching** method
5. **Evaluate** your design

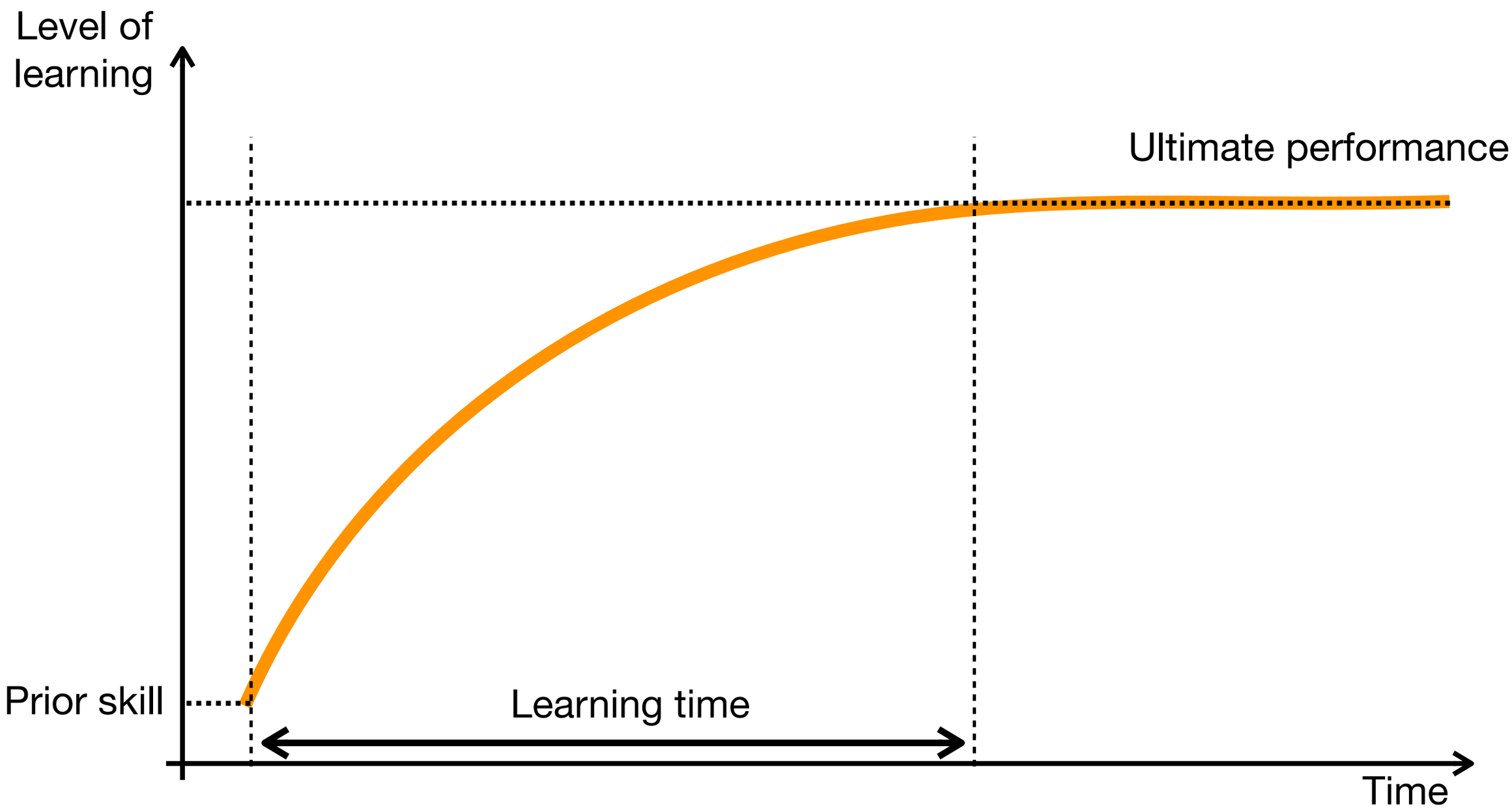
Learning curve



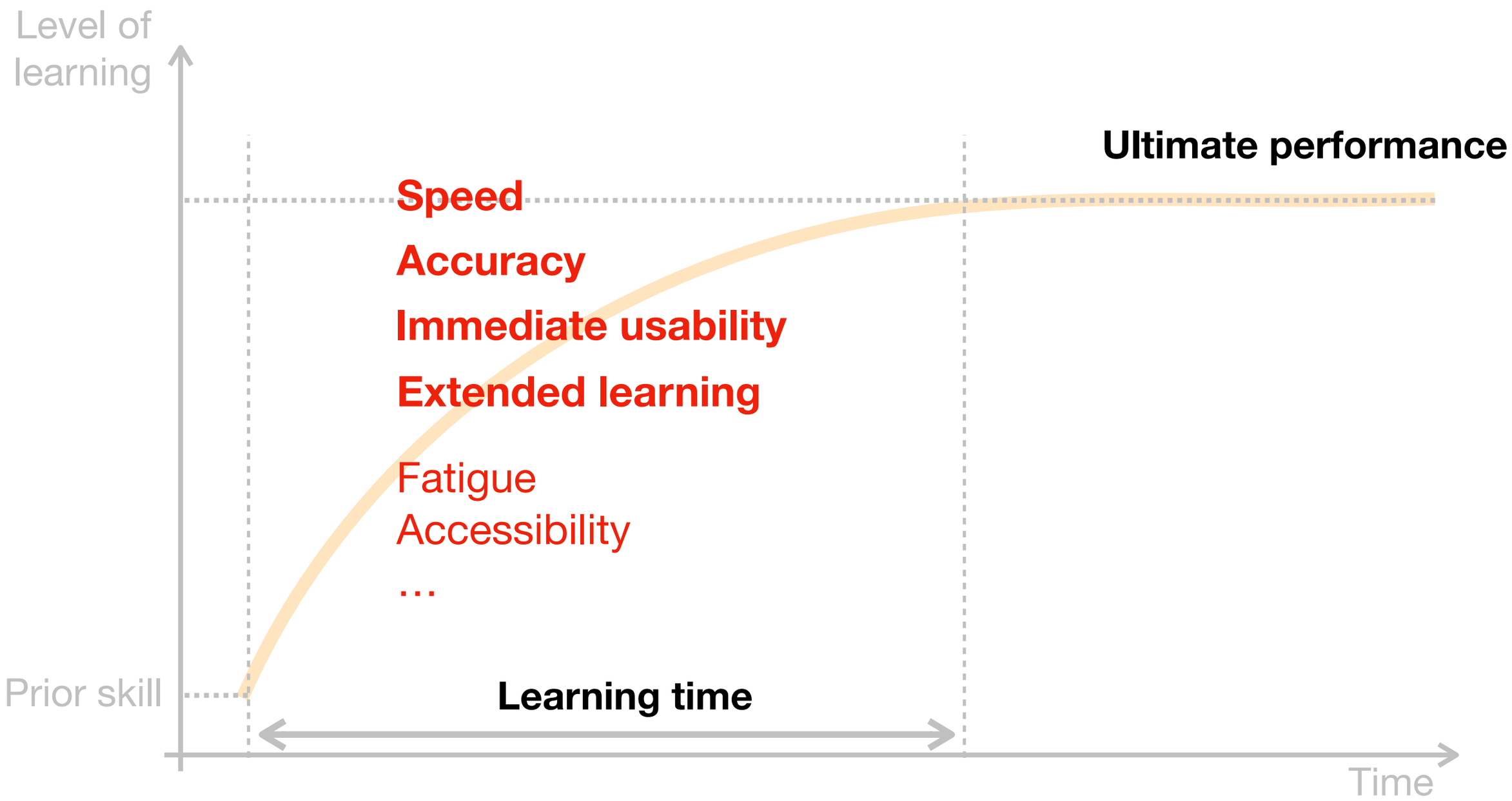
Learning curve



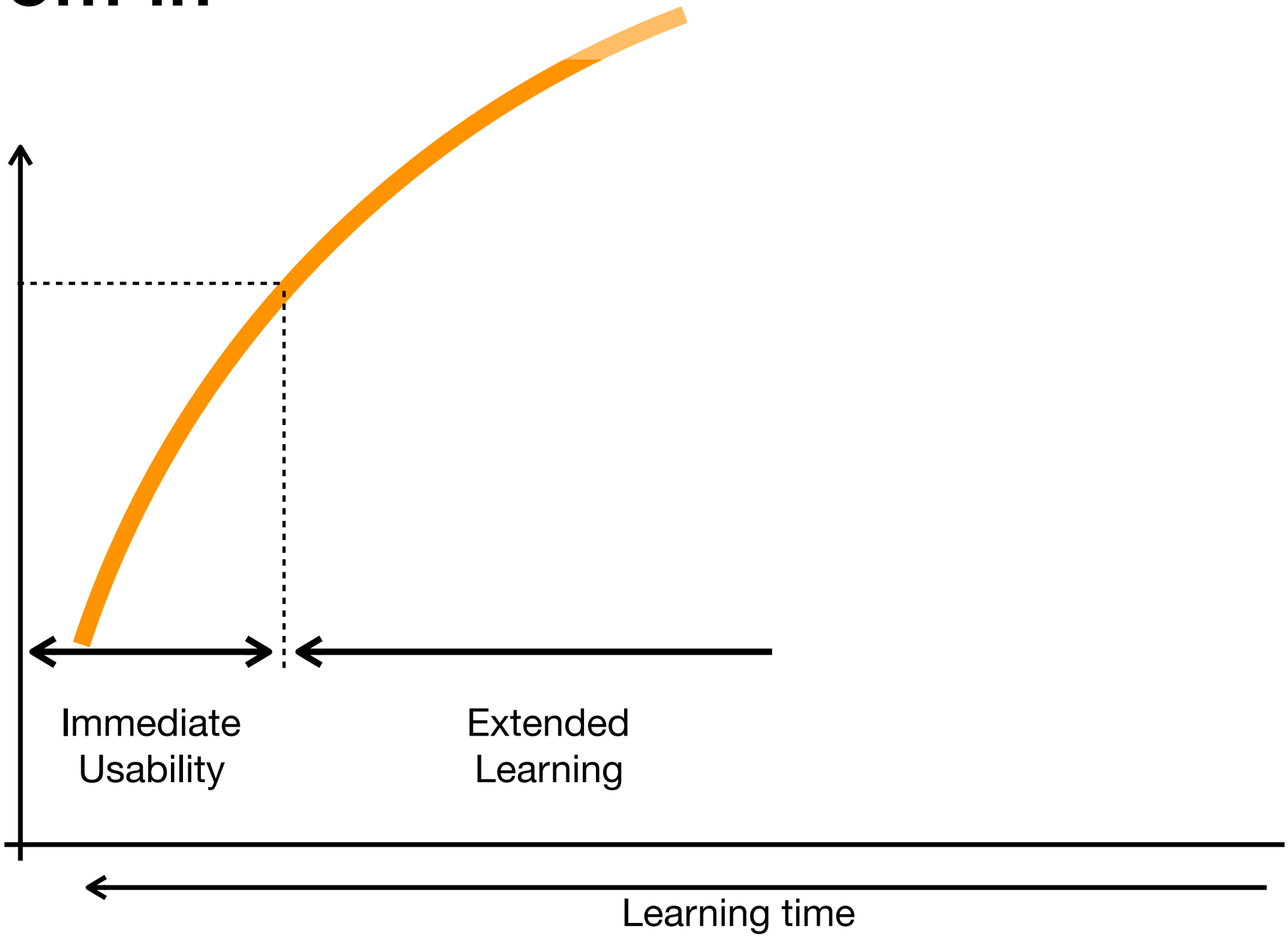
Learning curve



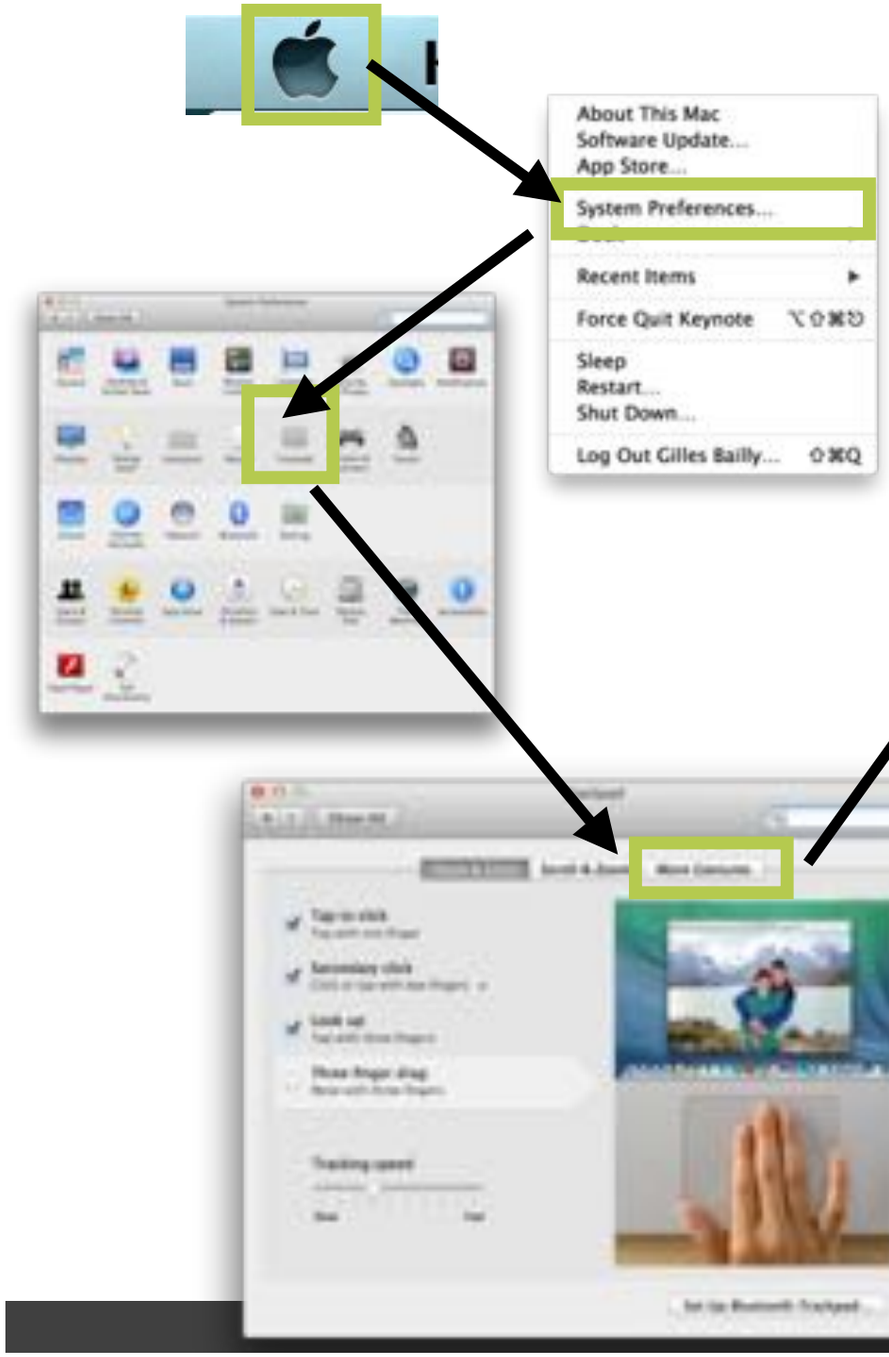
Criteria?


Level of learning
Ultimate performance
Speed
Accuracy
Immediate usability
Extended learning
Fatigue
Accessibility
…
Prior skill
Learning time
Time

Zoom in



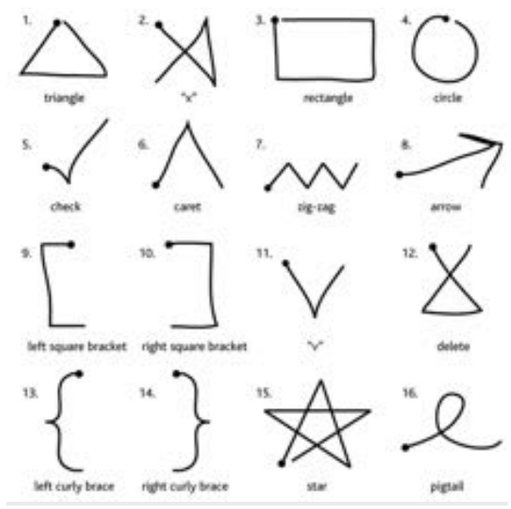
Cheat sheet


About This Mac
Software Update...
App Store...
System Preferences...
Recent Items
Force Quit Keynote
Sleep
Restart...
Shut Down...
Log Out Gilles Bailly...


Trackpad
Show All
Point & Click
Scroll & Zoom
More Gestures
Swipe between pages
Swipe between full-screen apps
Notification Center
Mission Control
App Exposé
Launchpad
Show Desktop
Set Up Bluetooth Trackpad...

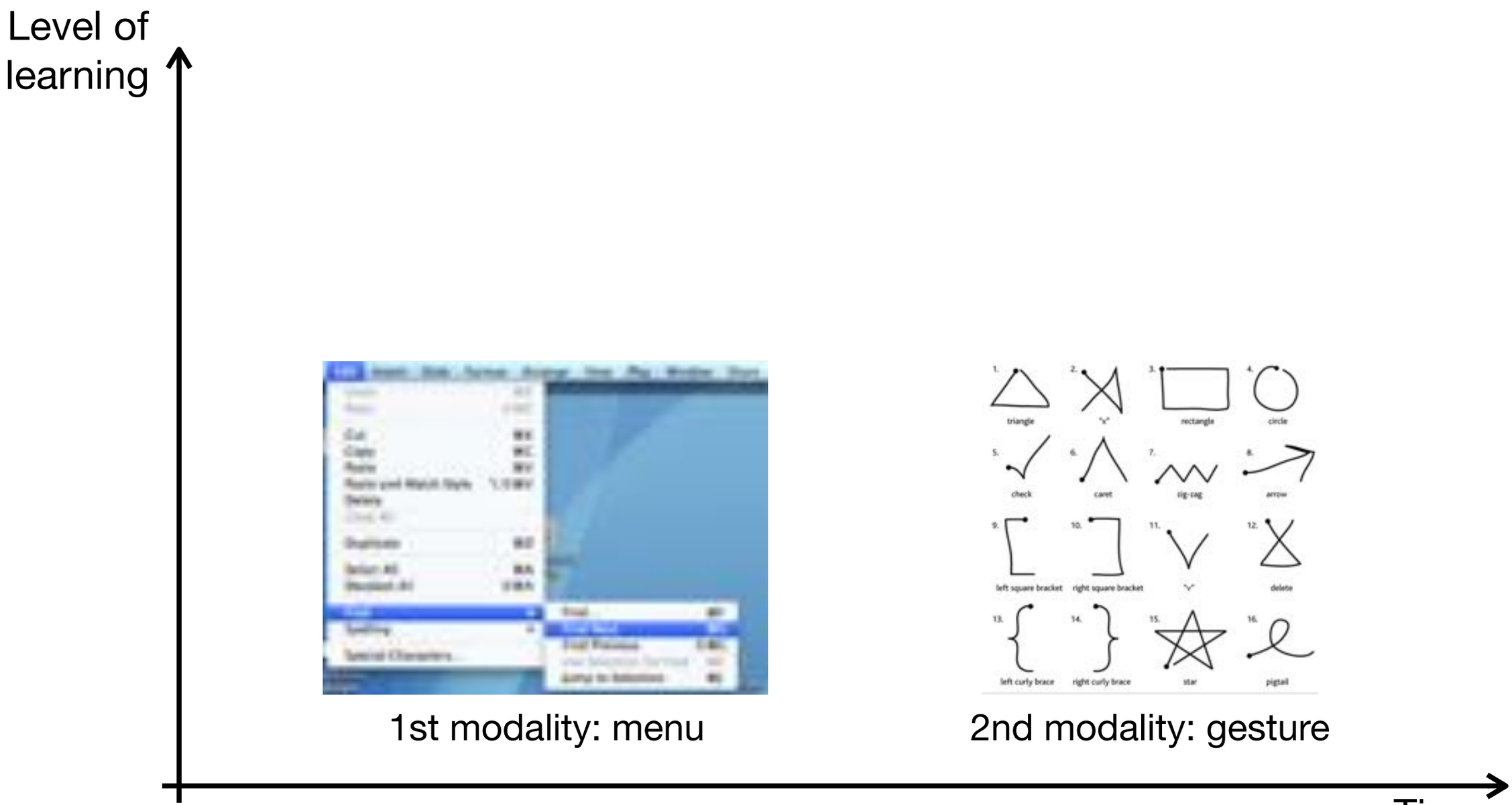
The case of two modalities

1st modality: menu

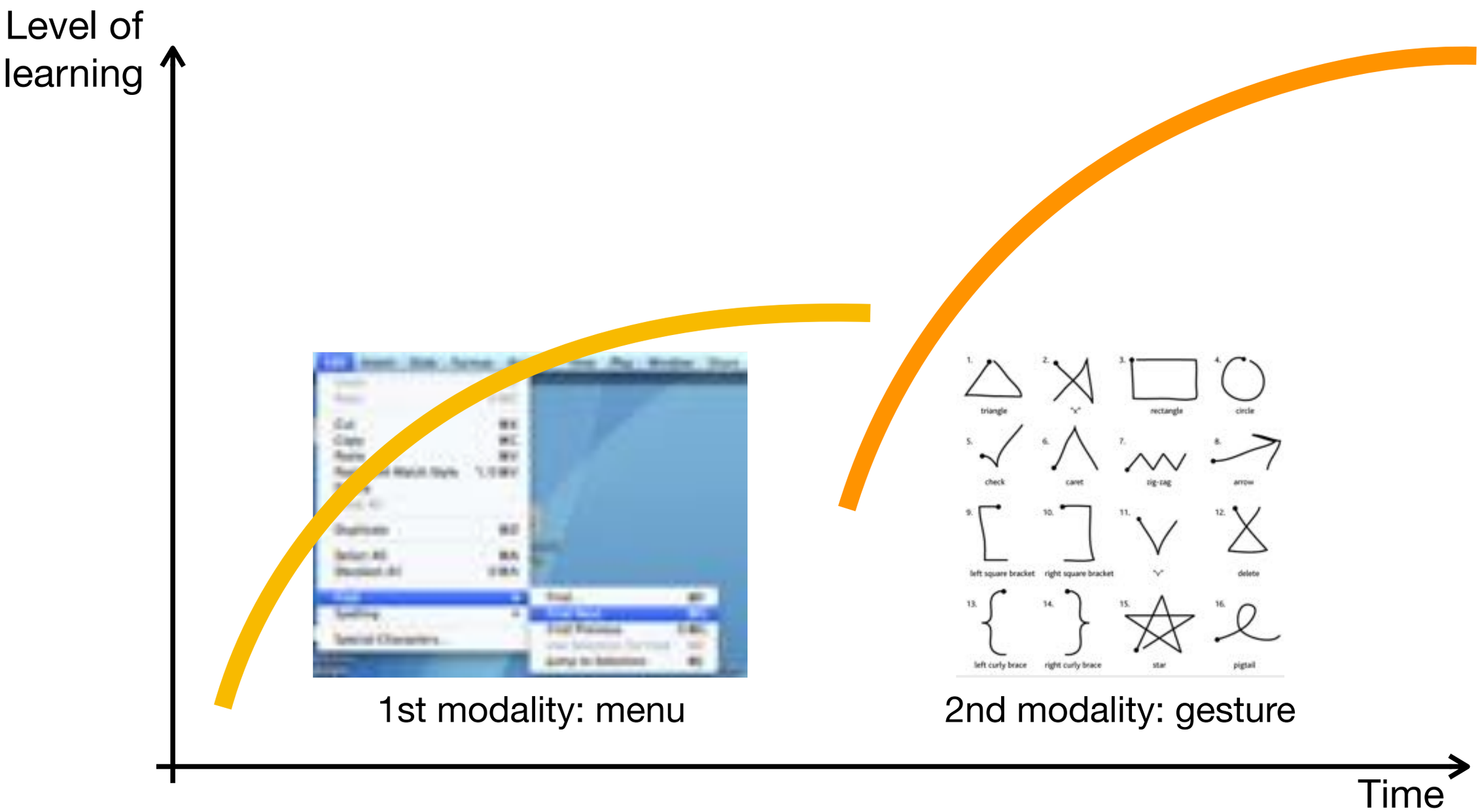


2nd modality: gesture

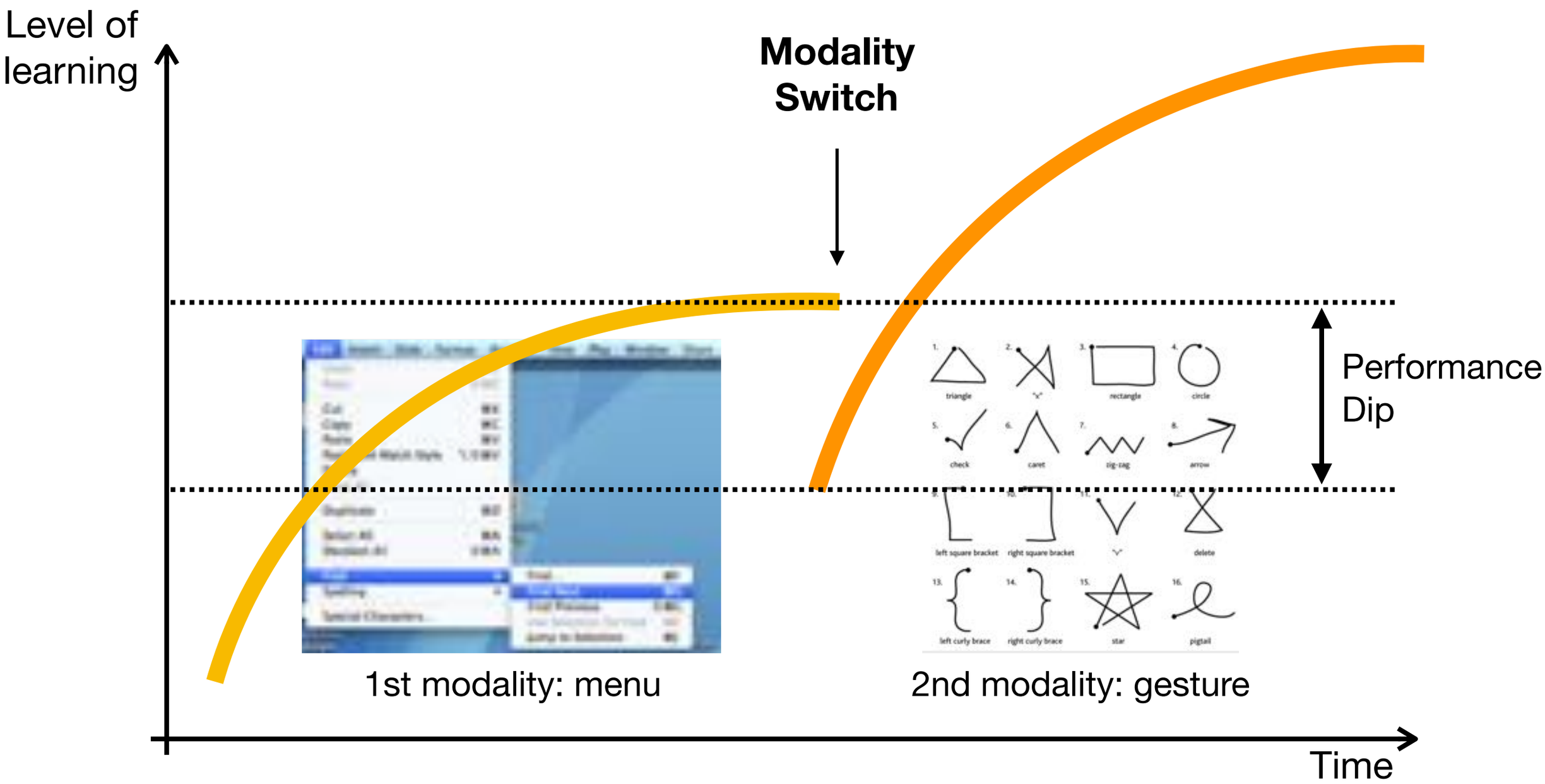
The case of two modalities



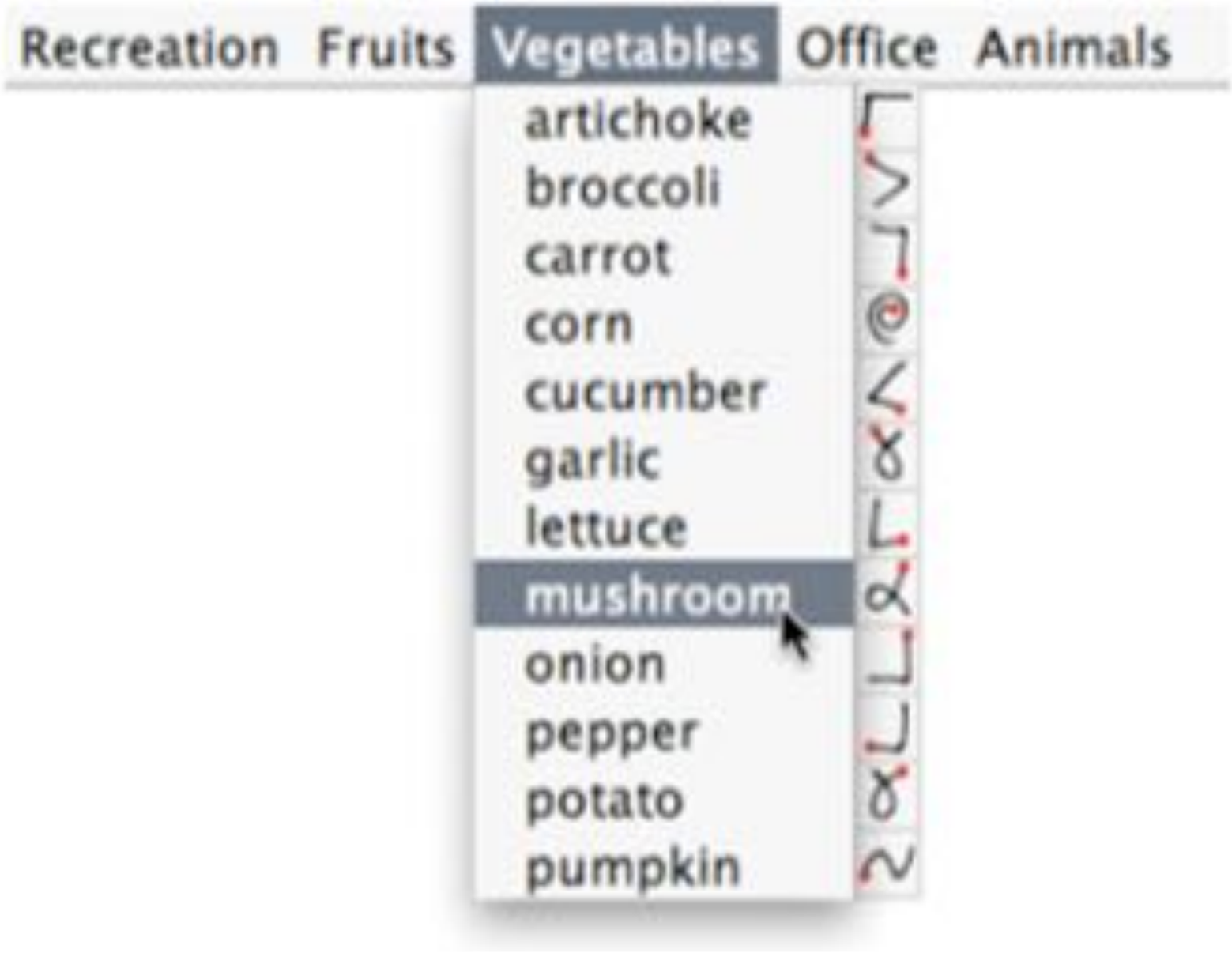
The case of two modalities



The case of two modalities



Example


Recreation
Fruits
Vegetables
Office
Animals
artichoke
broccoli
carrot
corn
cucumber
garlic
lettuce
mushroom
onion
pepper
potato
pumpkin

Guidance through feedforward

Bau, O., Mackay, W. OctoPocus: A Dynamic Guide for Learning Gesture-Based Command Sets. *UIST'08*

https://vimeo.com/2116172

Steps

Designing gestural interactions

1. ~~Create a **gesture set**~~
2. ~~Define a gesture-command **mapping**~~
3. ~~Build a gesture **recognizer**~~
4. ~~Provide a **teaching** method~~
5. **Evaluate** your design

Recognizer evaluation: gesture spotting

Can your system spot when a gesture starts and stops?

Recognizer evaluation: gesture spotting

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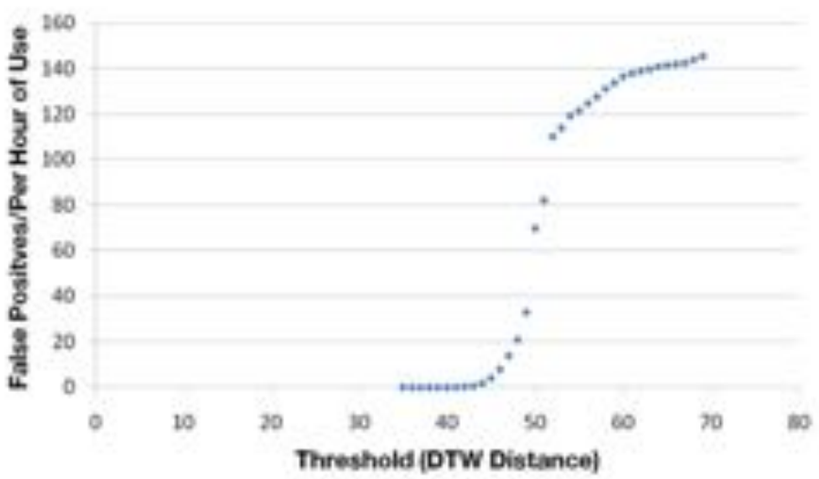


Figure 2: The DoubleFlip false positive rates versus distance threshold level.

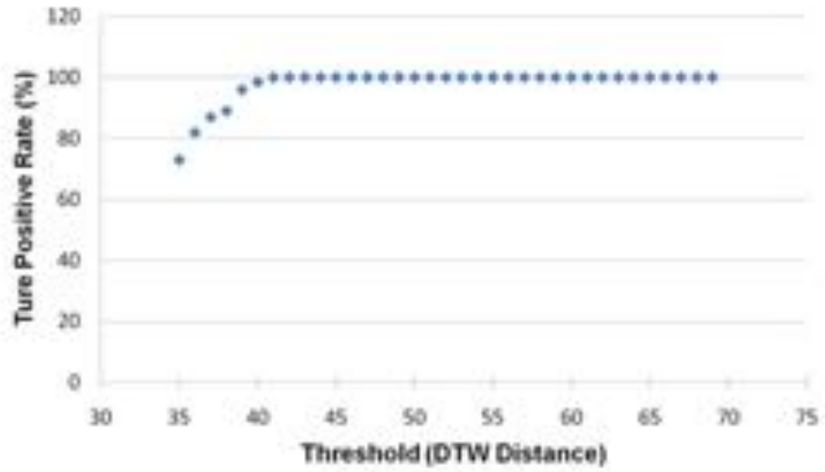


Figure 3: The DoubleFlip true positive rate versus distance threshold level.

Ruiz, J., Li, Y. DoubleFlip: A Motion Gesture Delimiter for Mobile Interaction. *CHI'2011*

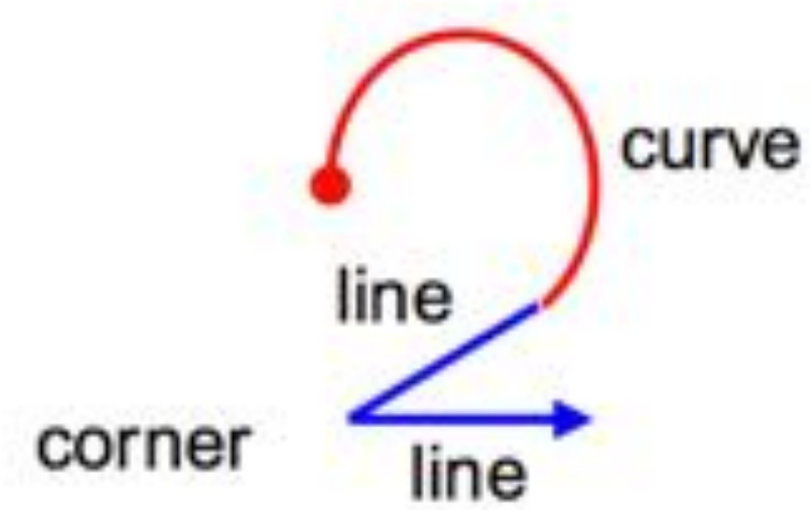
Motor control: model of performance

Gesture characteristics impact gesture timing

Motor control: model of performance

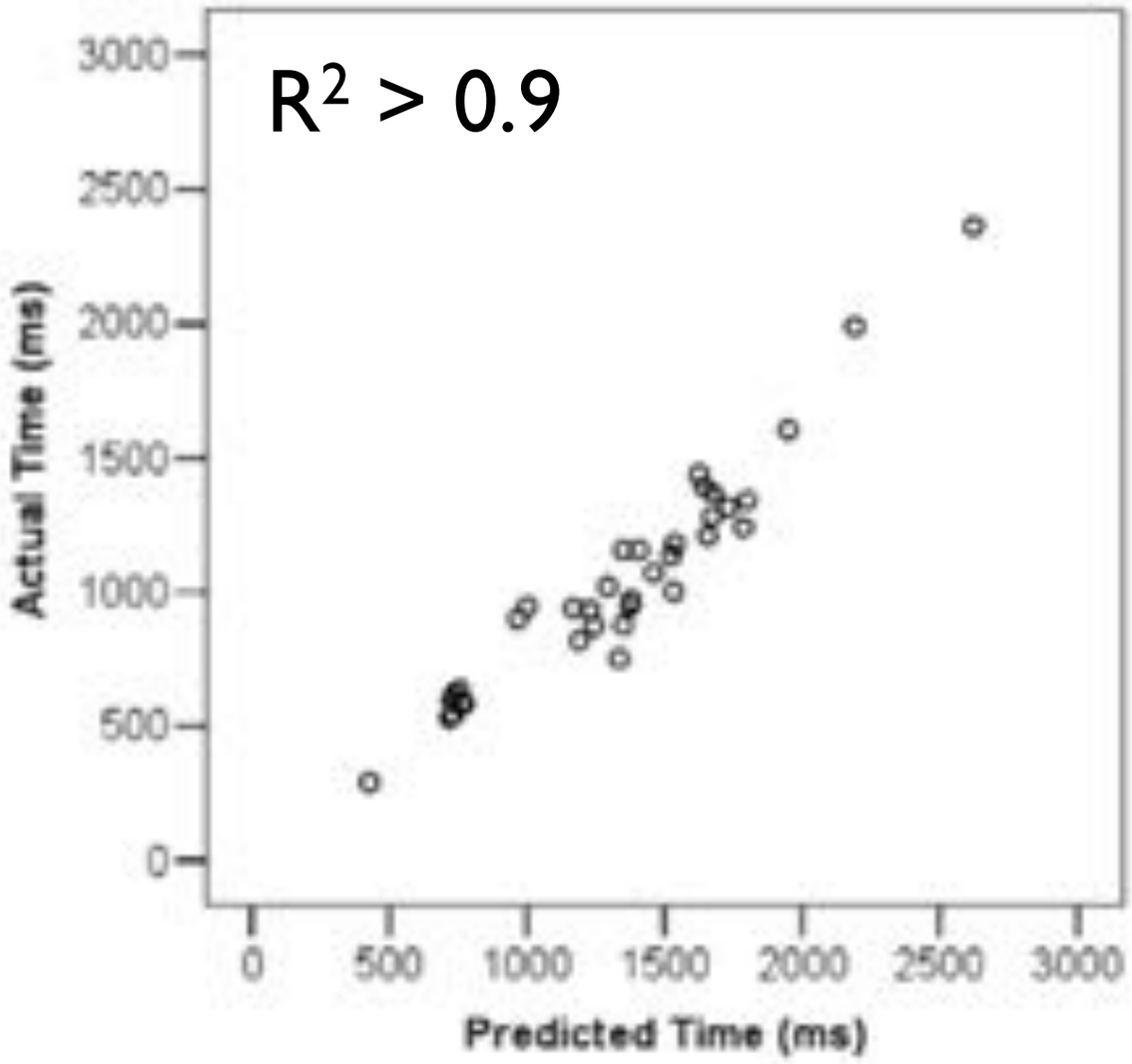
Gesture characteristics impact gesture timing

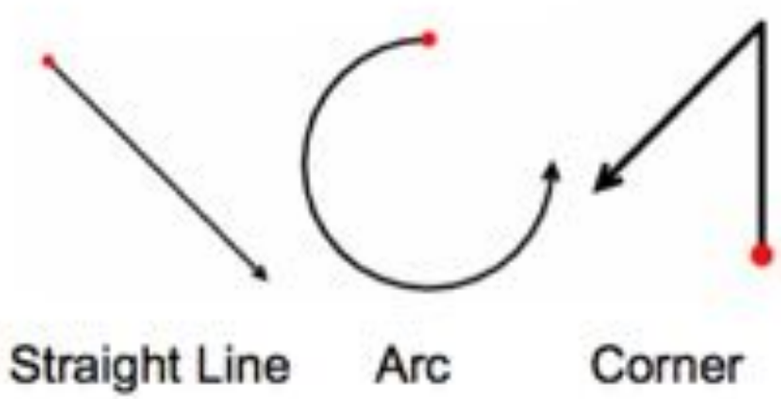
$$T = \sum T(\text{line}) + \sum T(\text{corner}) + \sum T(\text{curve}).$$

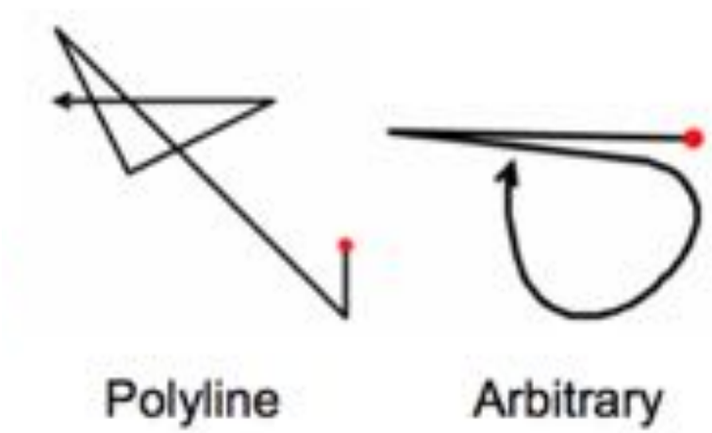


Cao, X., Zhai, S. Modeling Human Performance of Pen Stroke Gestures. *CHI'07*

Motor control: model of performance







Cao, X., Zhai, S. Modeling Human Performance of Pen Stroke Gestures. *CHI'07*

Don’t forget user experience!

Don’t forget user experience!

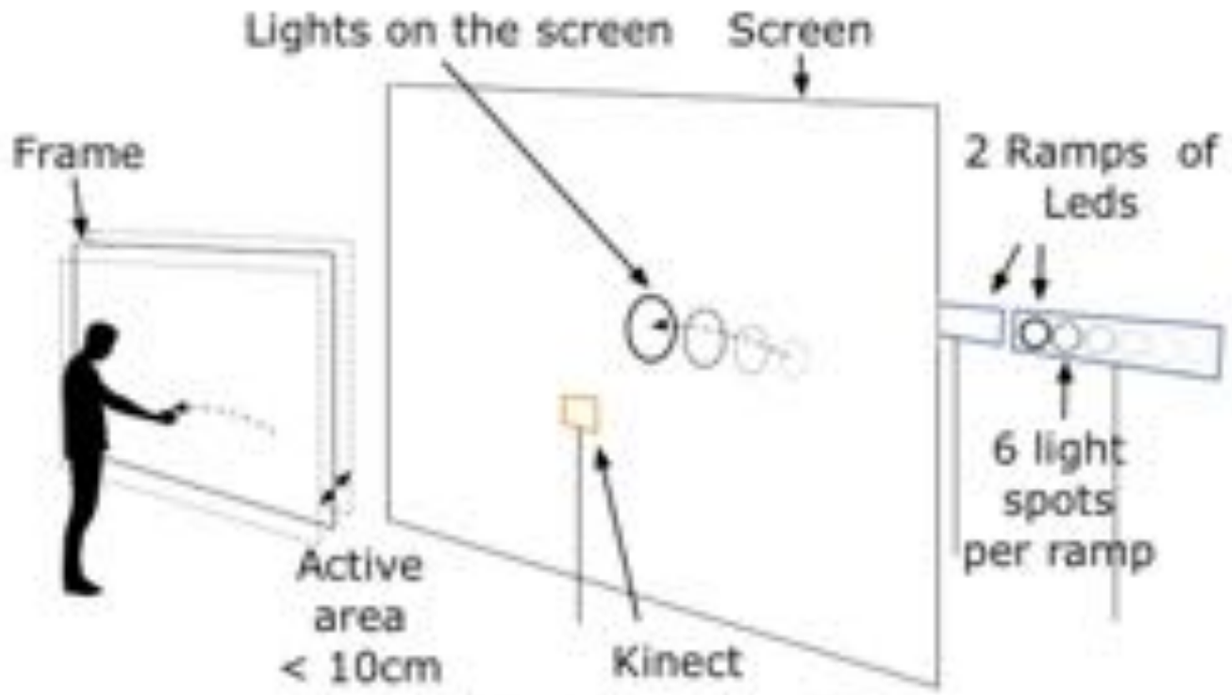


Figure 7. Installation description.

Movement quality-based vs. Point-based interaction

Fdili Alaoui, S., Caramiaux B., Serrano, M., Bevilacqua, F. Movement Qualities as Interaction Modality. *DIS’12*

Lab study

Assessing learning criteria speed, accuracy?

Procedure

- Target participants (novices, experts, etc…)
- Ask the participants to perform varying tasks (variations are usually controlled, “independent variables”, and can be different interaction techniques)
- Compute speed and accuracy for each task (“dependent variables”)
- Conclude on the effect of the interaction technique on speed/accuracy

Pros: controlled, replicable, “cheap”

Cons: does not always reflect real world situations

Guidelines

1. Motivate the use of gestures in your interactive design

2. Make gestures accessible to novices

3. Make gestures as simple as possible for immediate usability, make gestures learnable otherwise

4. Monitor recognizer accuracy and gesture spotting

5. Make consistent feedback and feedforward processes

6. Assess not only usability, also user experience, attractiveness, expressiveness and skill acquisition