Lecture

Designing Gestural Interaction

Baptiste Caramiaux

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?

Designing gestural interactions

...

Steps

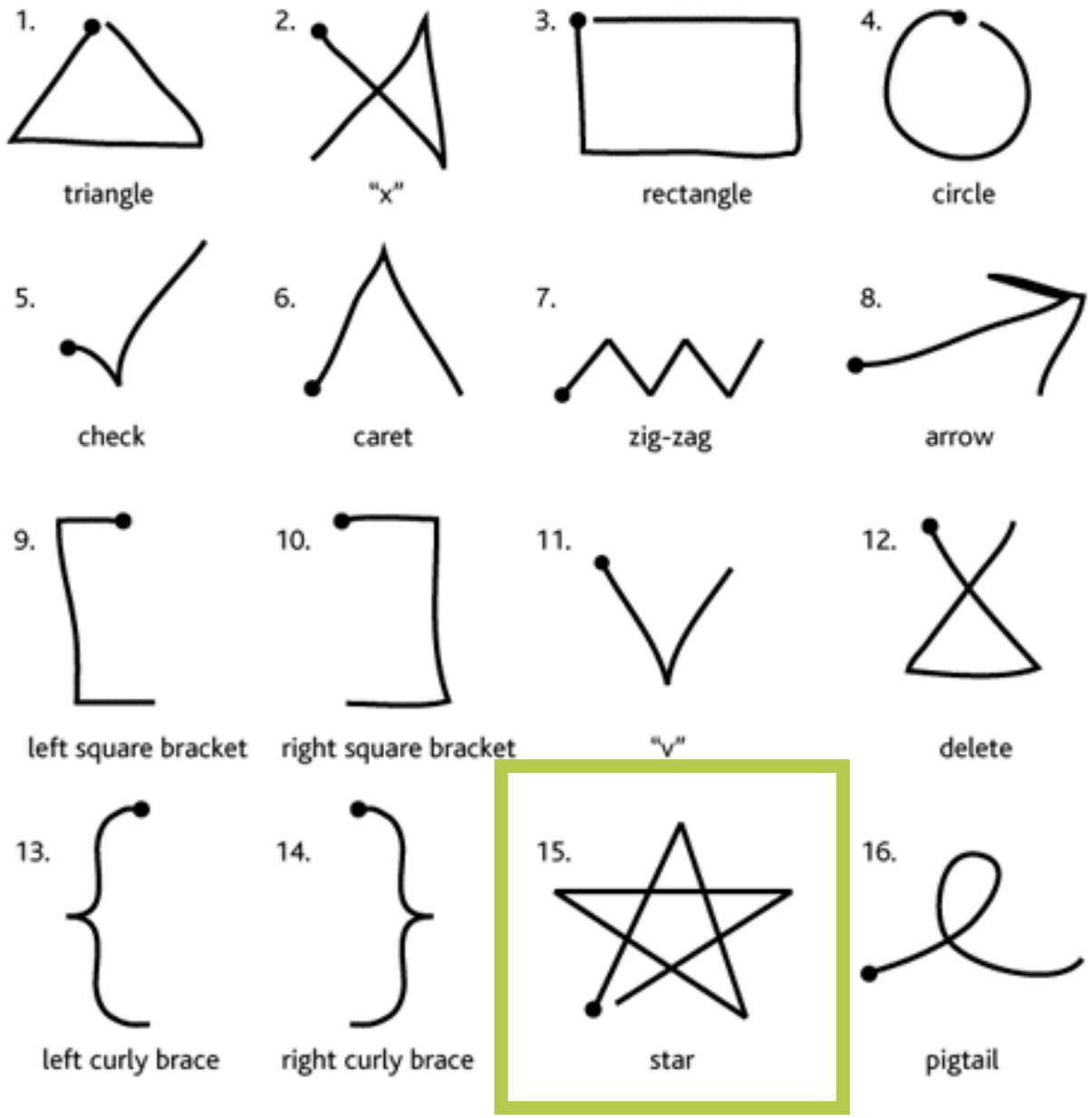
Designing gestural interactions

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

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

User-centred approach

Goal

- Capture “natural” mappings

User-centred approach

Goal

- Capture “natural” mappings

Procedure:

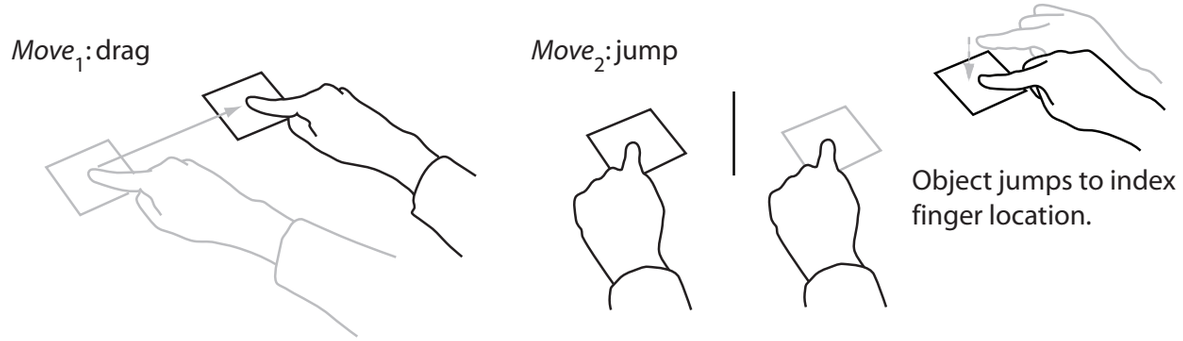
- Several users
- The experimenter shows the effect
- Users have to guess the gesture
- For each command, keep the most frequent gesture

User-centred approach

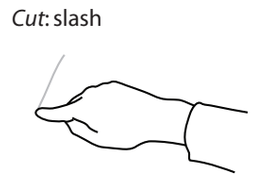
Examples on a touch surface

- 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)

Is it a good technique?

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

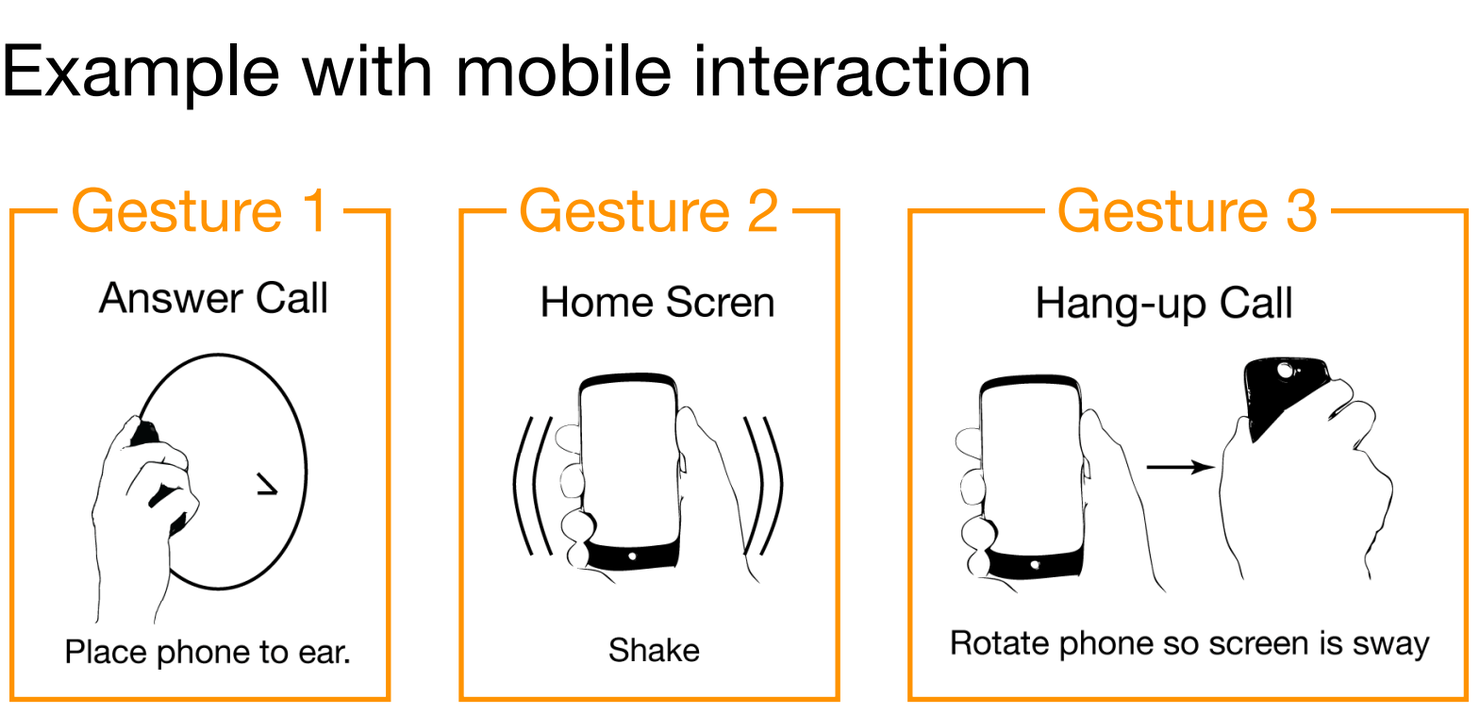
Problem: does work for a tiny set of gestures

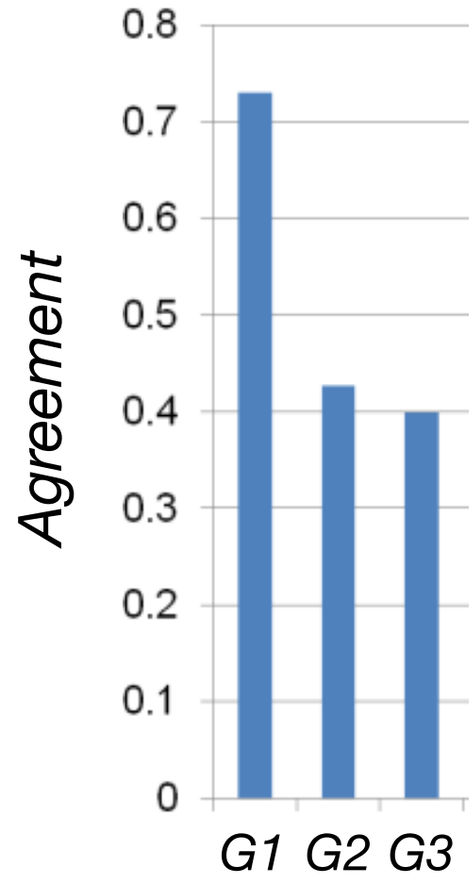
Is it a good technique?

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

Problem: does work for a tiny set of gestures

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?

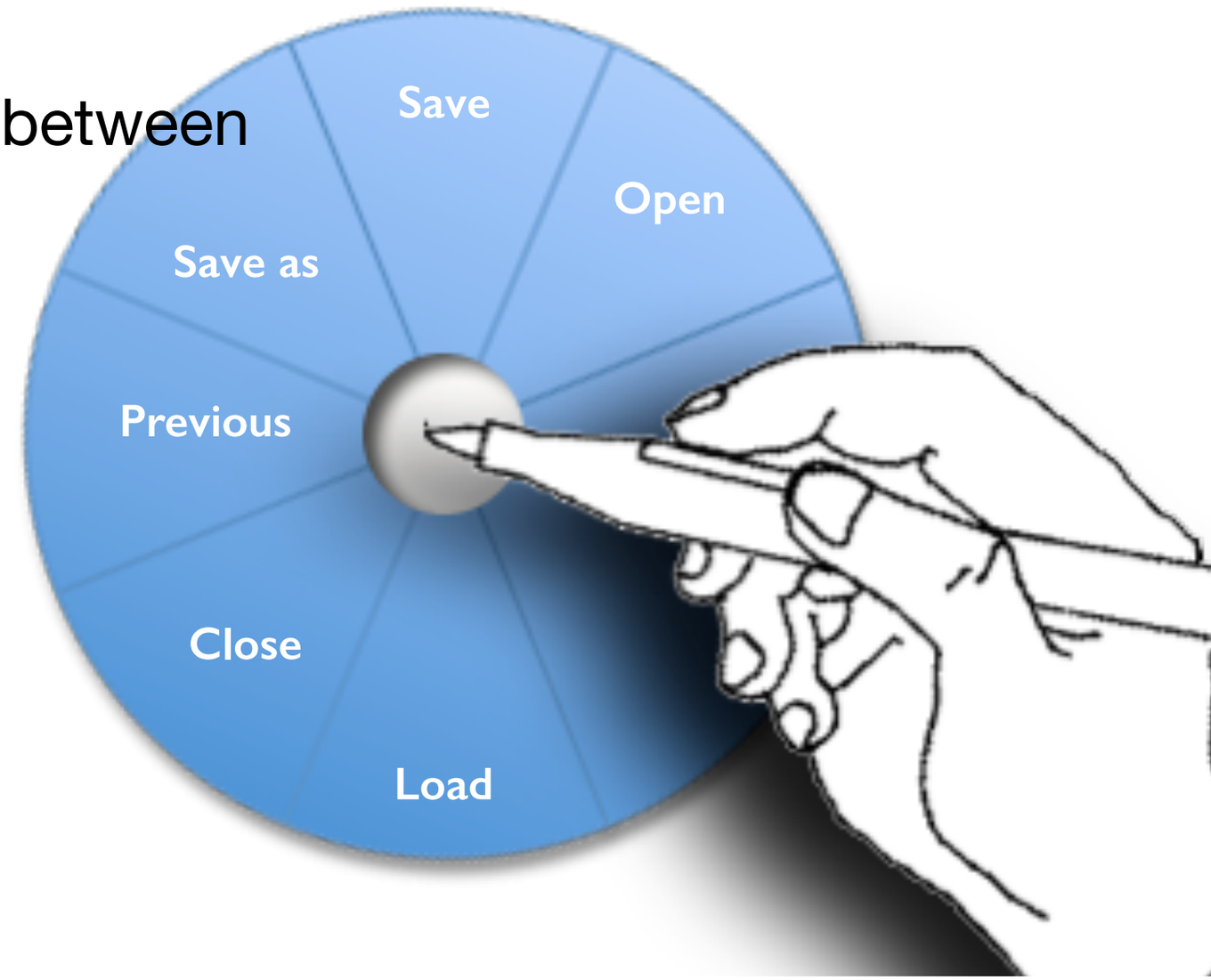
Other approaches

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**
4. Provide a **teaching** method
5. **Evaluate** your design

Gesture recognition

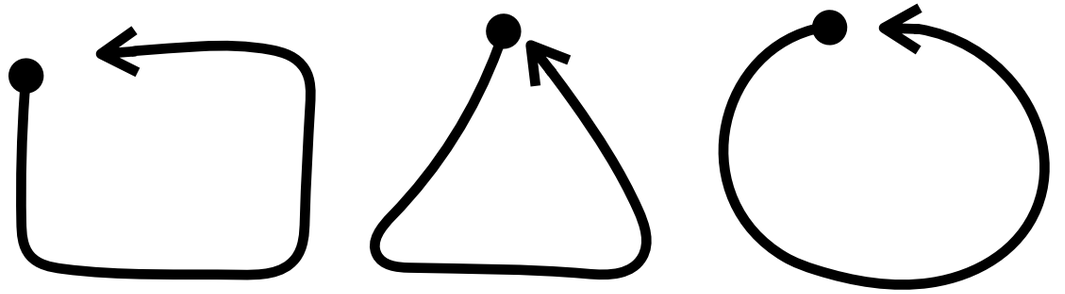
A gesture **recognizer** is a system able to take an **unknown input gesture** and **classify** it as being one element of a predefined **set of gestures** (**vocabulary**).

Two important strategies

- Template-based approach
- Training-based approach

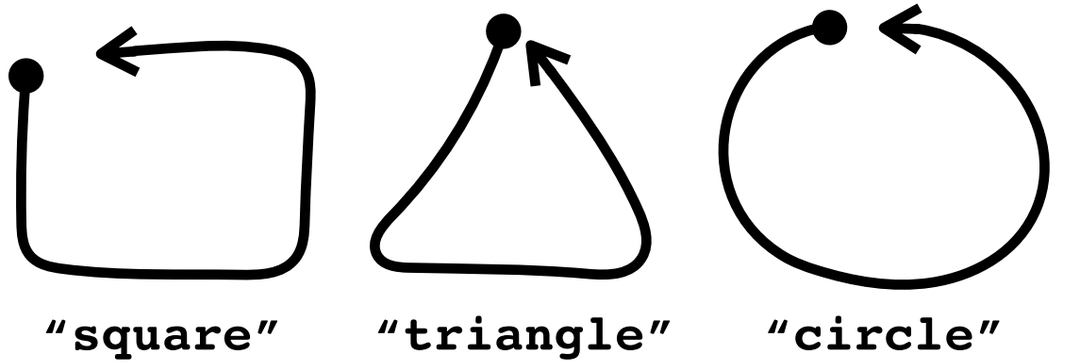
Template-based

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

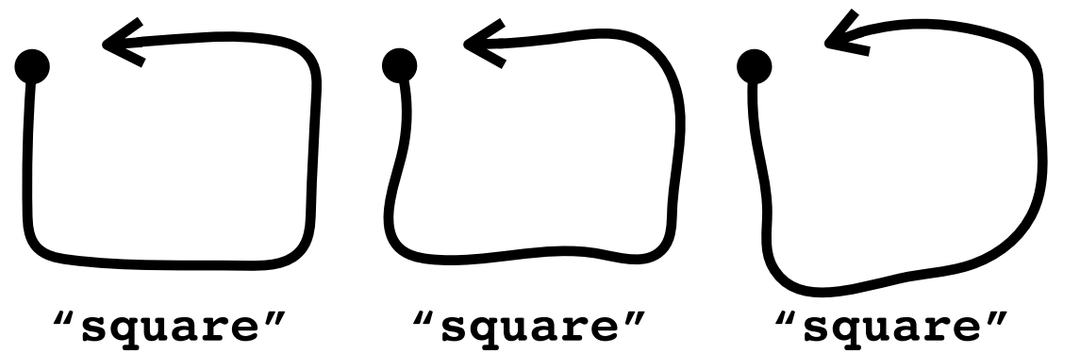


Template-based

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

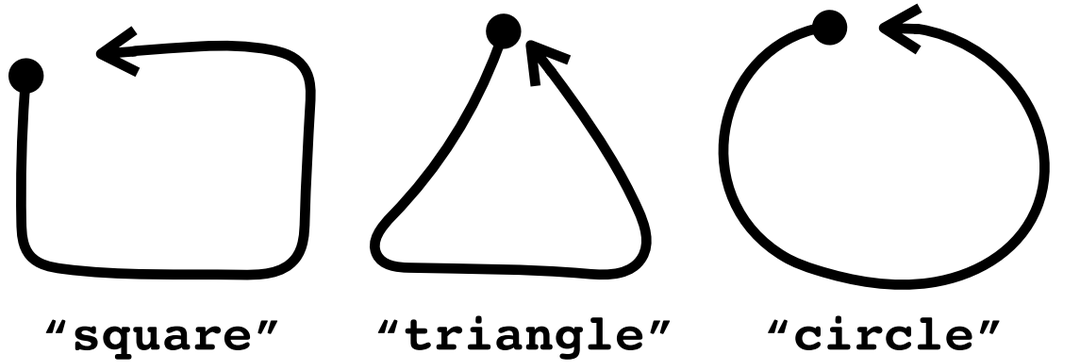


Each recorded gesture can be recorded once or multiple times (with the **same label**)

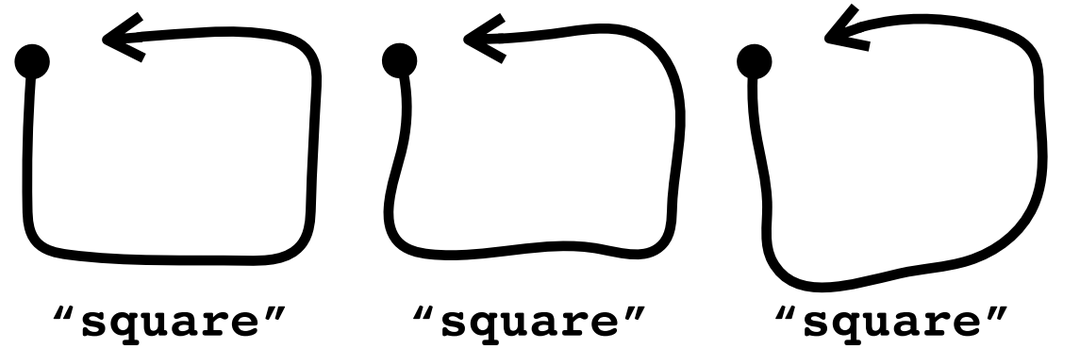


Template-based

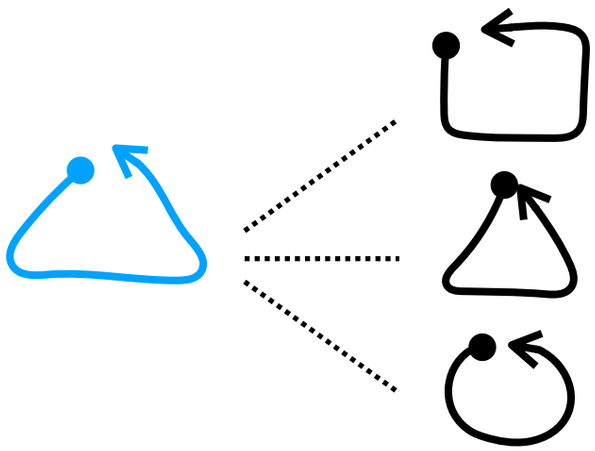
Record a set of gestures (**vocabulary**) and assign a label to each gesture



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

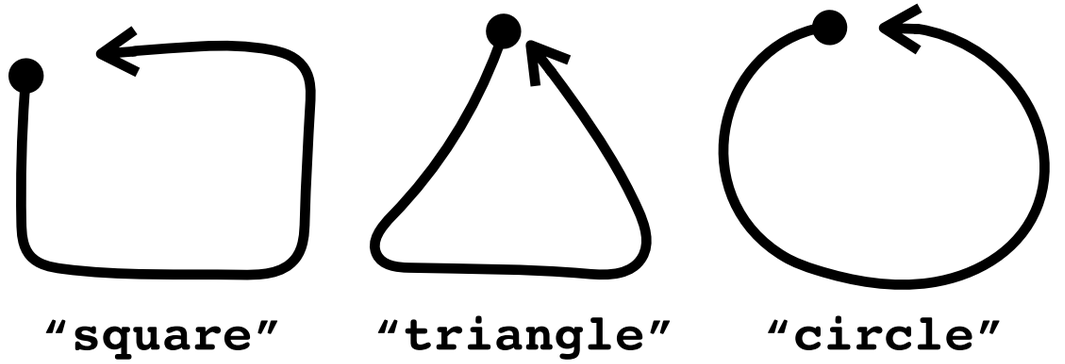


For an input unknown gesture, compute distance between the input gesture and the pre-recorded gestures

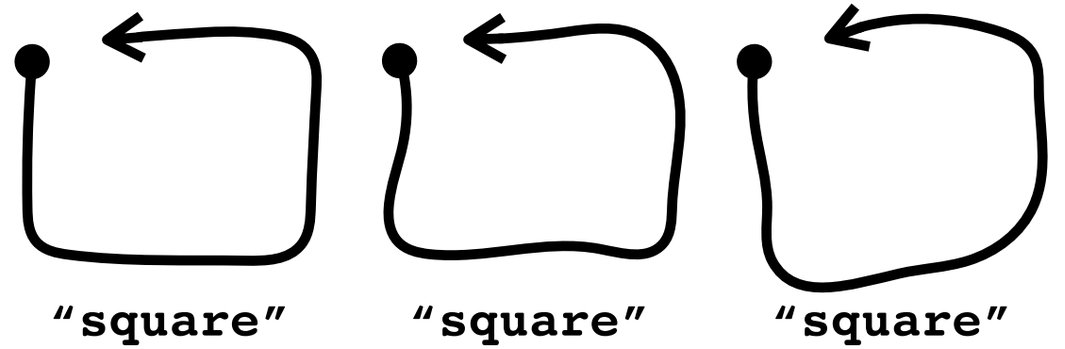


Template-based

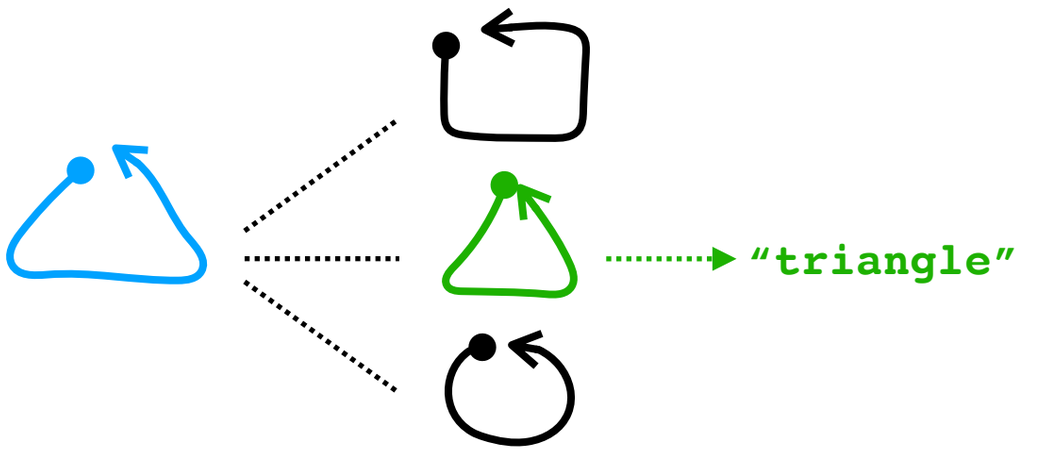
Record a set of gestures (**vocabulary**) and assign a label to each gesture



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



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



Return gesture label w.r.t smallest distance value

Examples

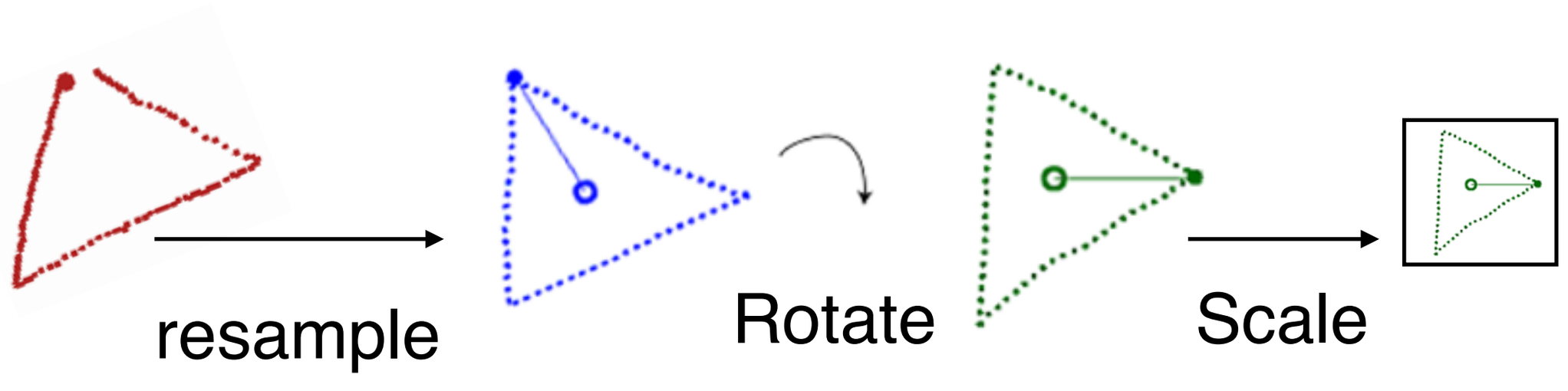
HCI literature

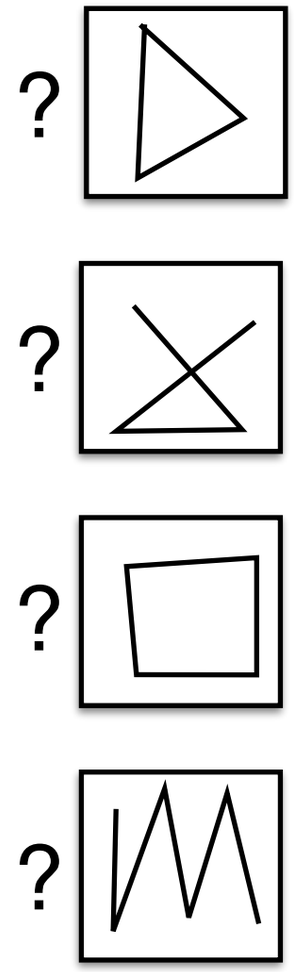
- Rubine (Rubine, 1991)
- $1 recognizer (Wobbrock et al. 2007)

Machine-learning literature

- k-Nearest Neighbor
- Dynamic Time Warping for classification

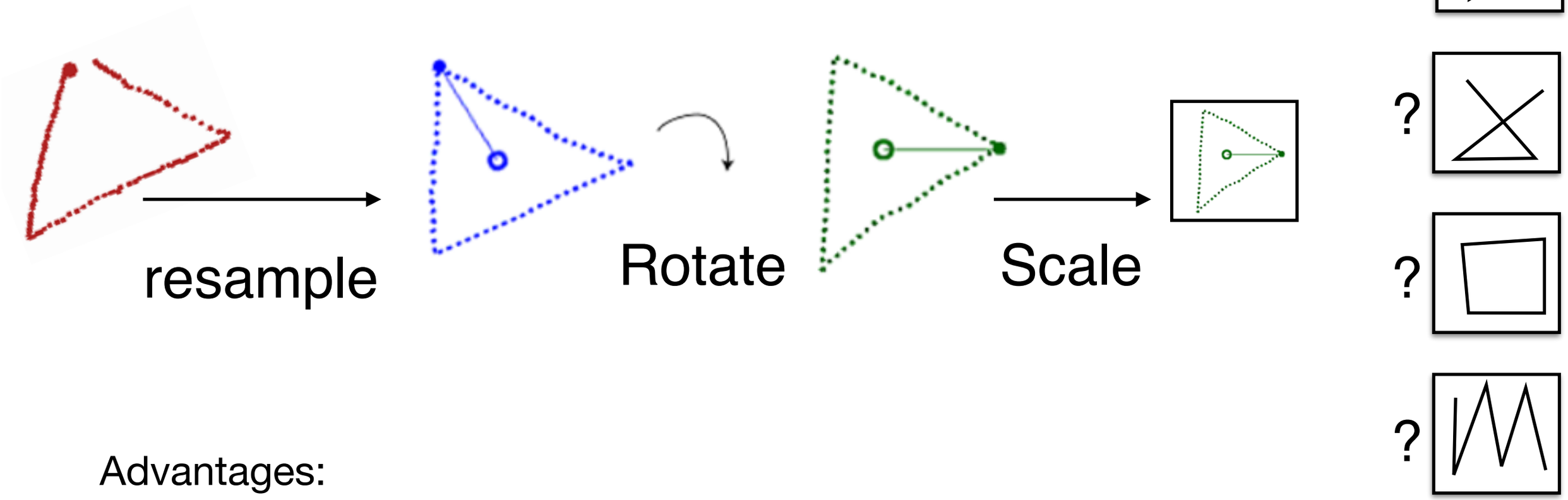
$1 recognizer





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

$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”

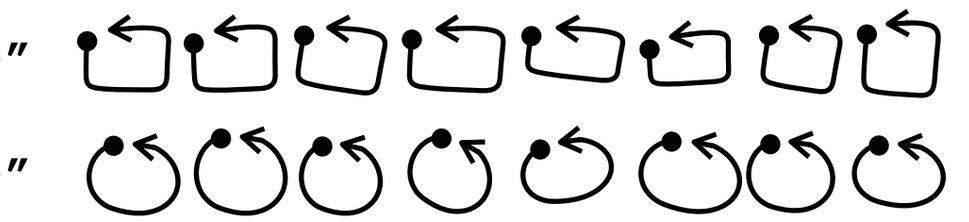
“circle”

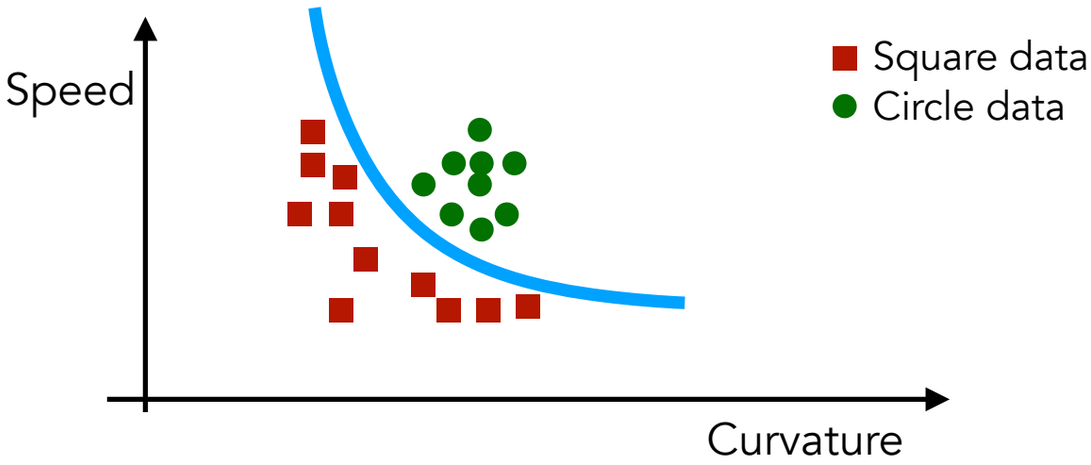
Training-based approach

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

“square”

“circle”



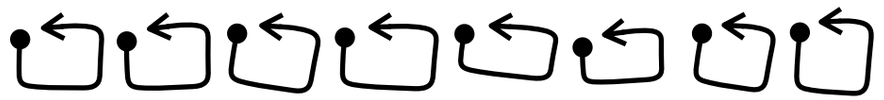


Build a **model** allowing for discriminating “square” data from “circle” data

Training-based approach

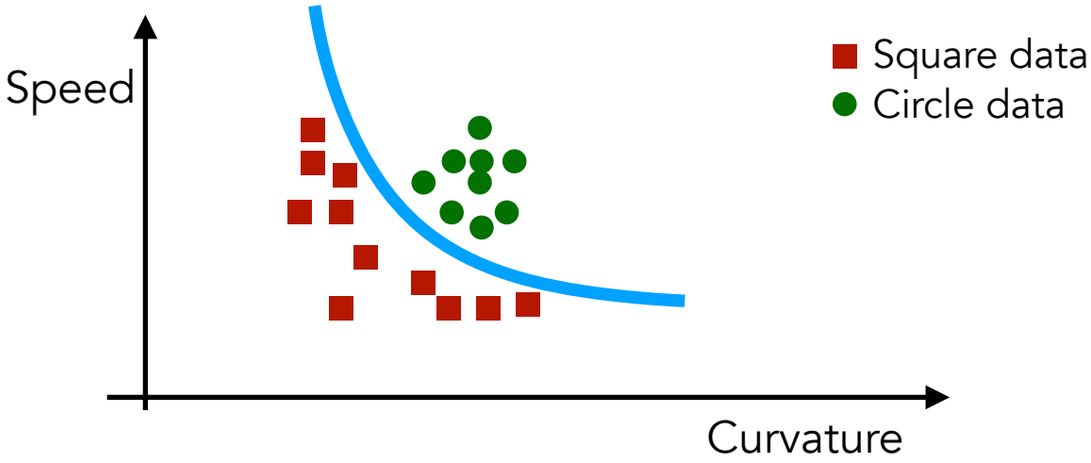
Record **several** examples of a set of gestures and assign a label to each gesture

“square”

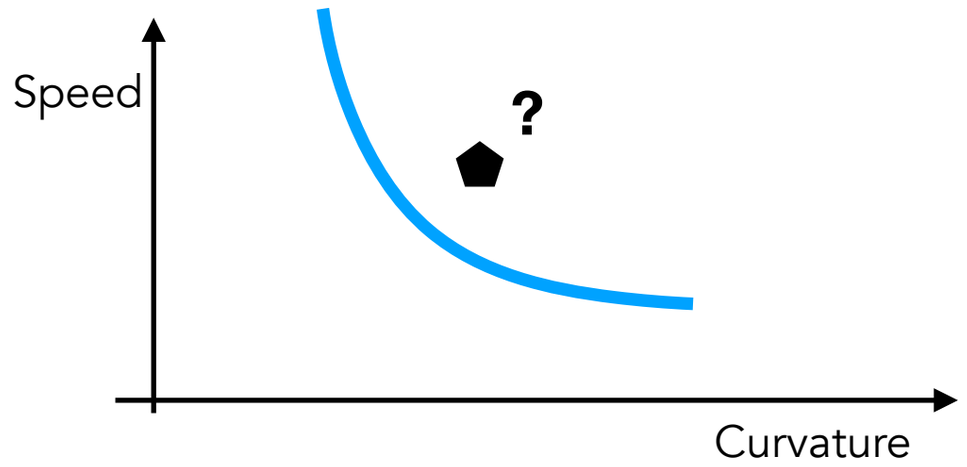


“circle”

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

Cf. Lecture on "Gesture Recognition and Machine Learning"

Choosing a gesture recognizer

Complexity of the input data

- 2-d drawn gestures
- Accelerometers/gyroscopes
- Video-based …

Pose gestures or dynamic gestures

Need for a lot of examples for training

Generalisability etc…

Choosing a gesture recognizer

Complexity of the input data

- 2-d drawn gestures
- Accelerometers/gyroscopes
- Video-based …

Pose gestures or dynamic gestures

Need for a lot of examples for training

Generalisability etc…

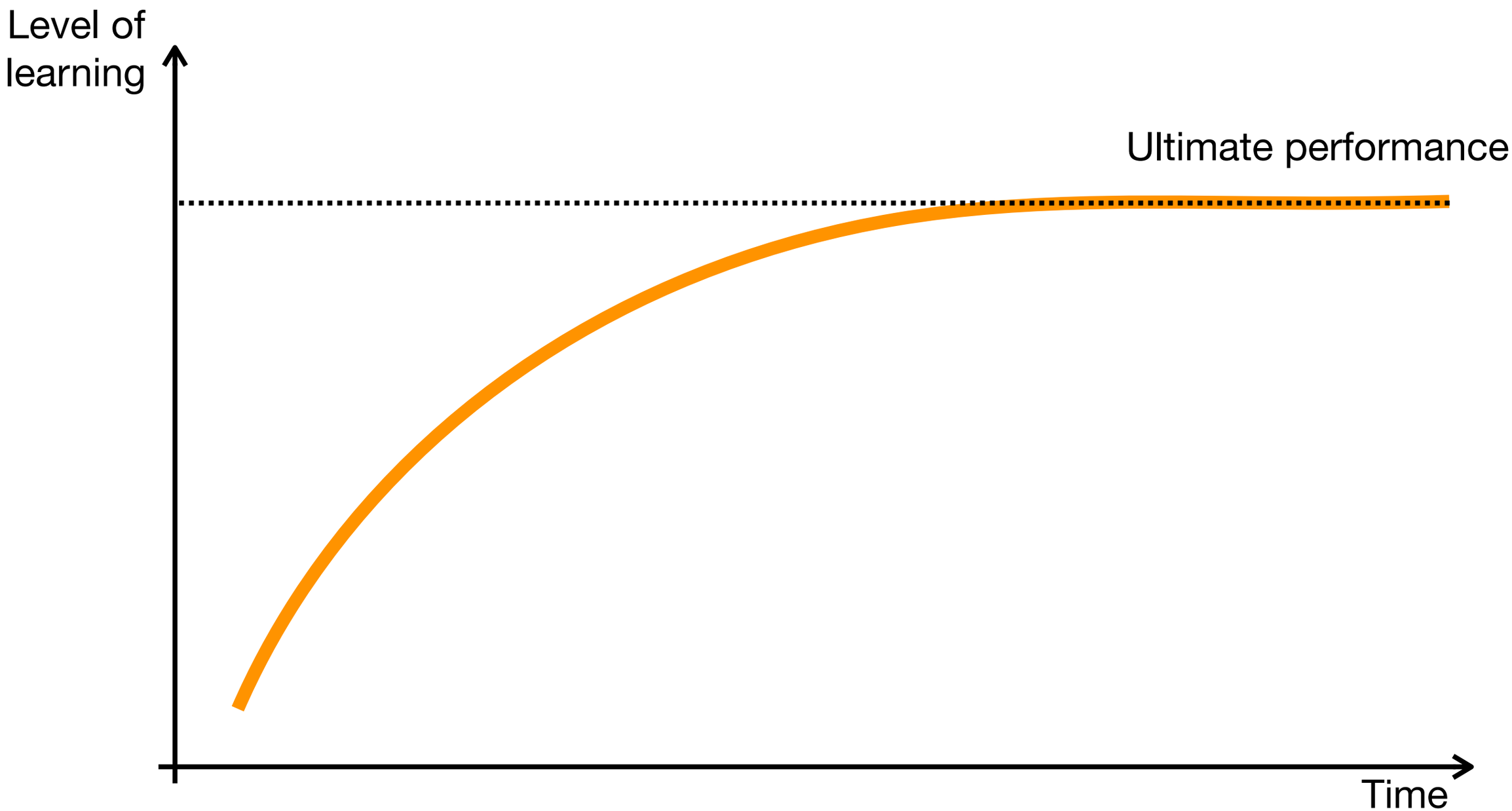
=> *Keep track of the state of the art!*

Steps

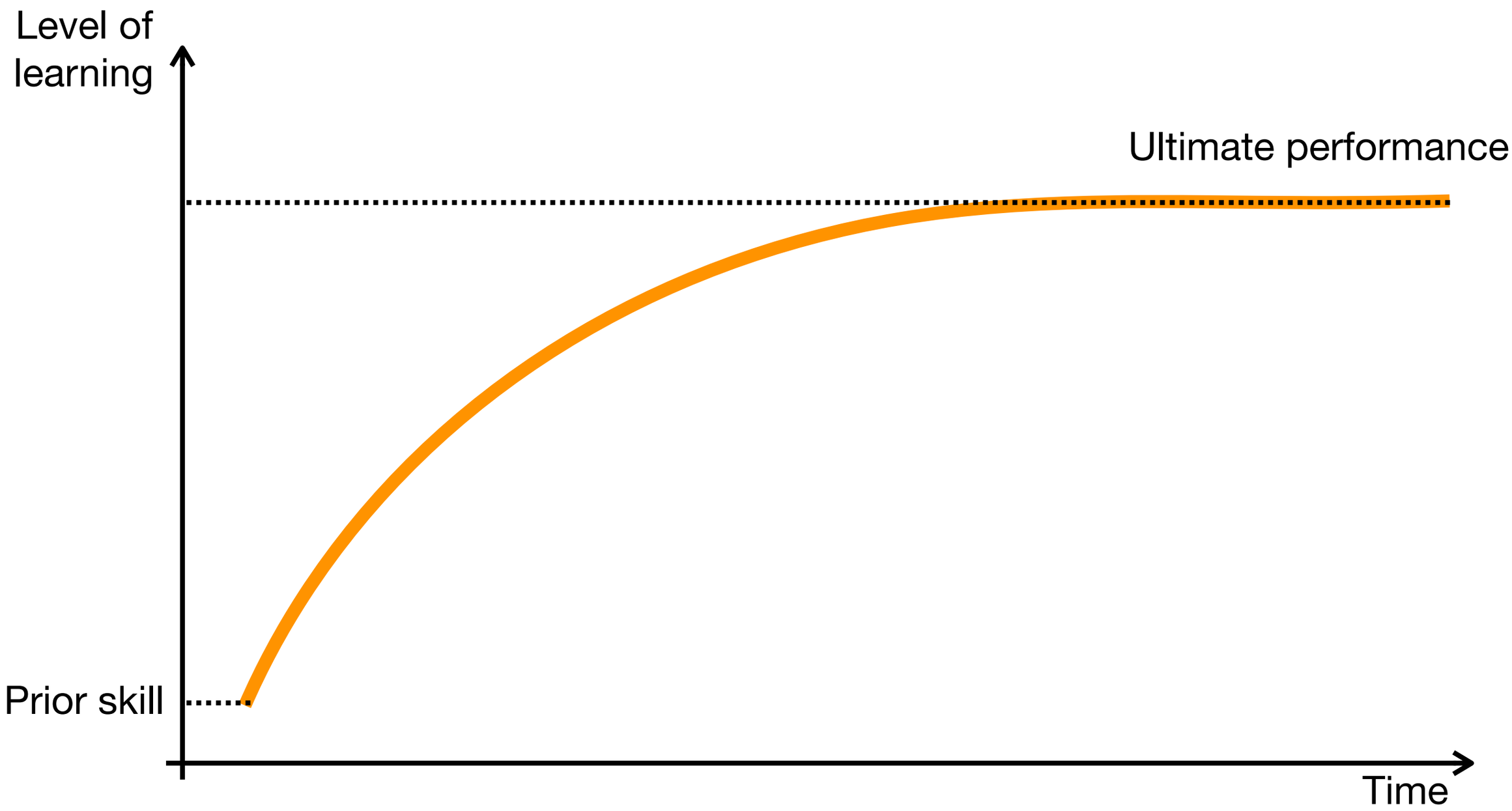
Designing gestural interactions

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

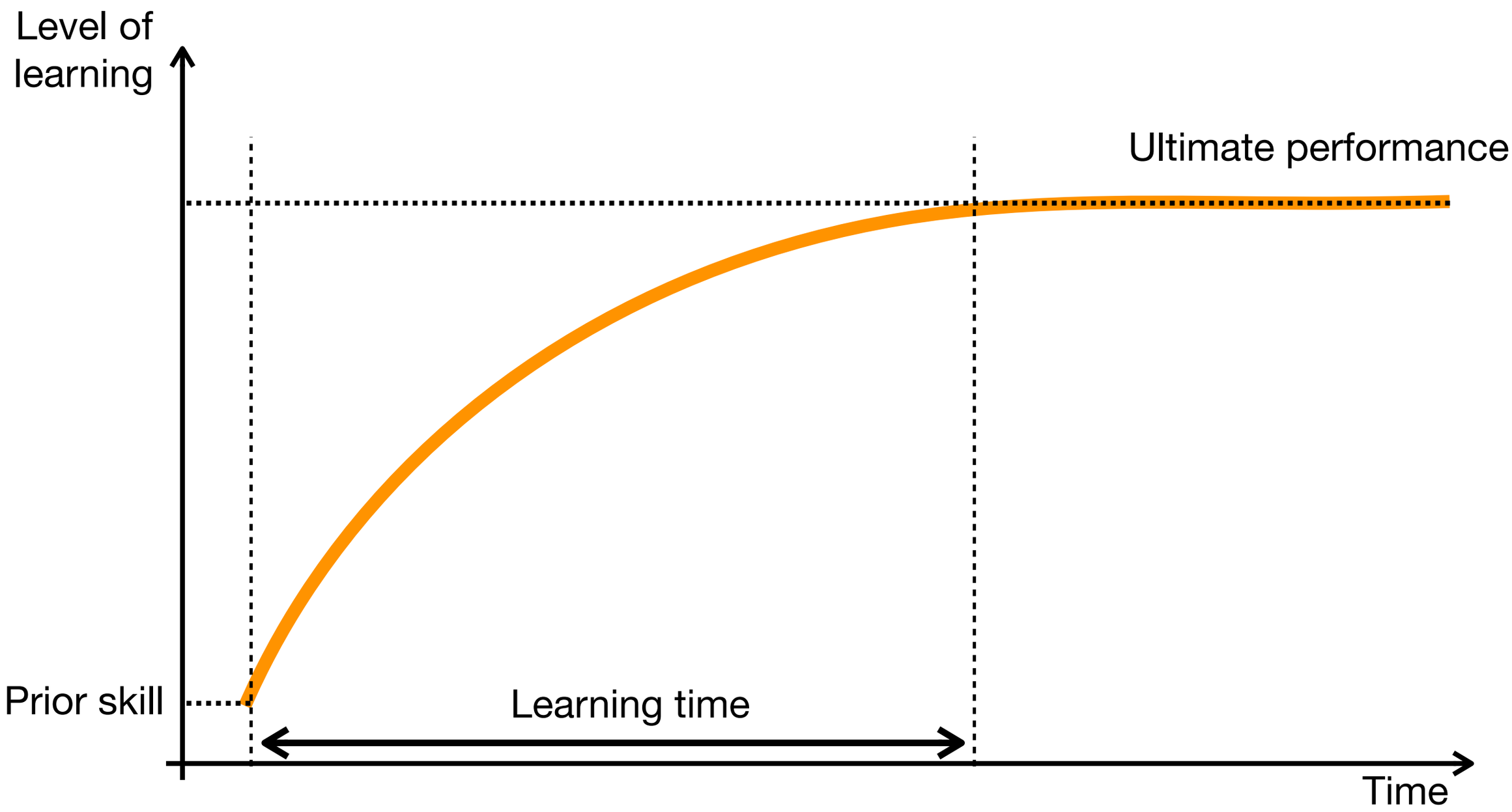
Learning curve



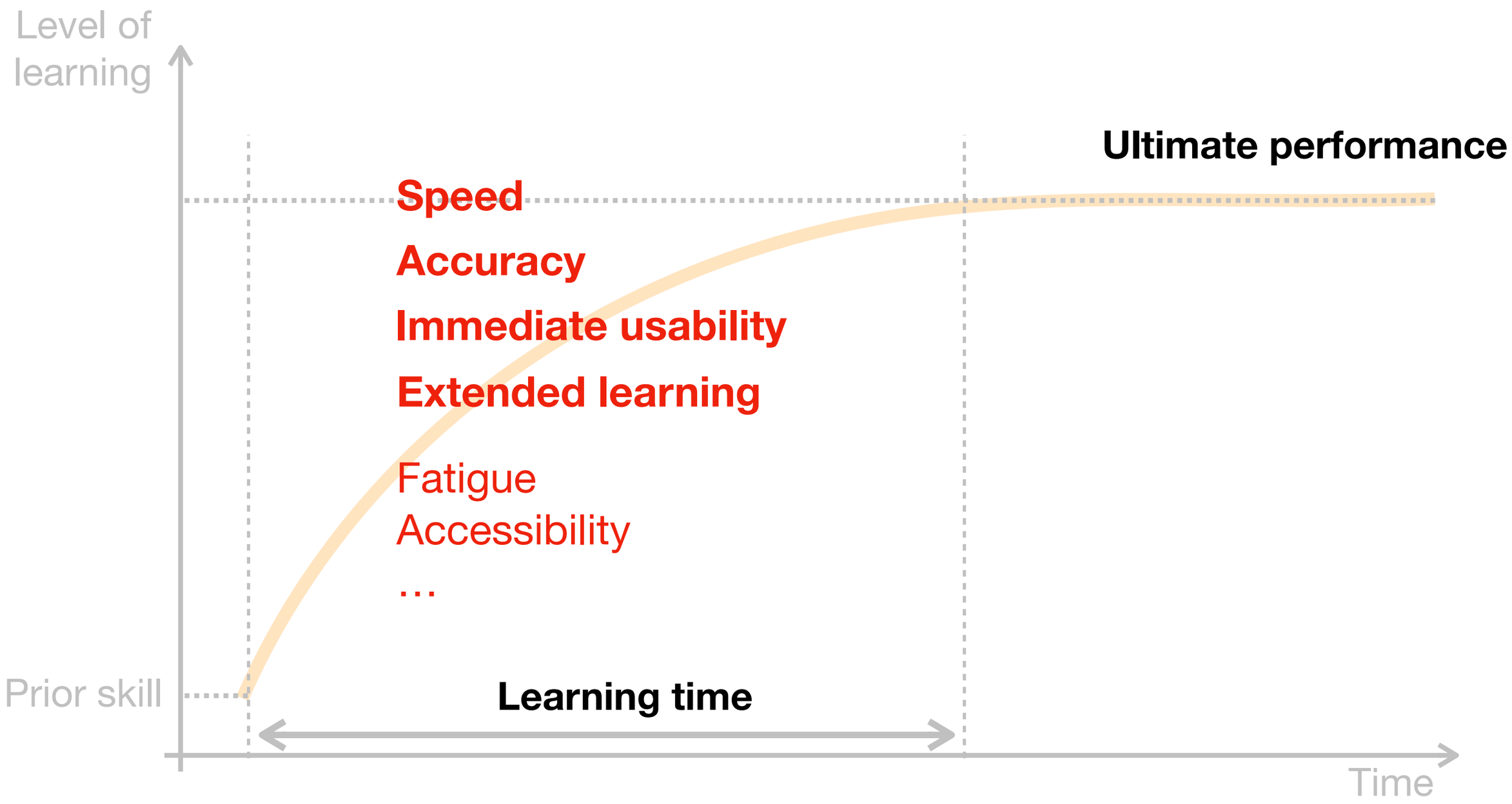
Learning curve



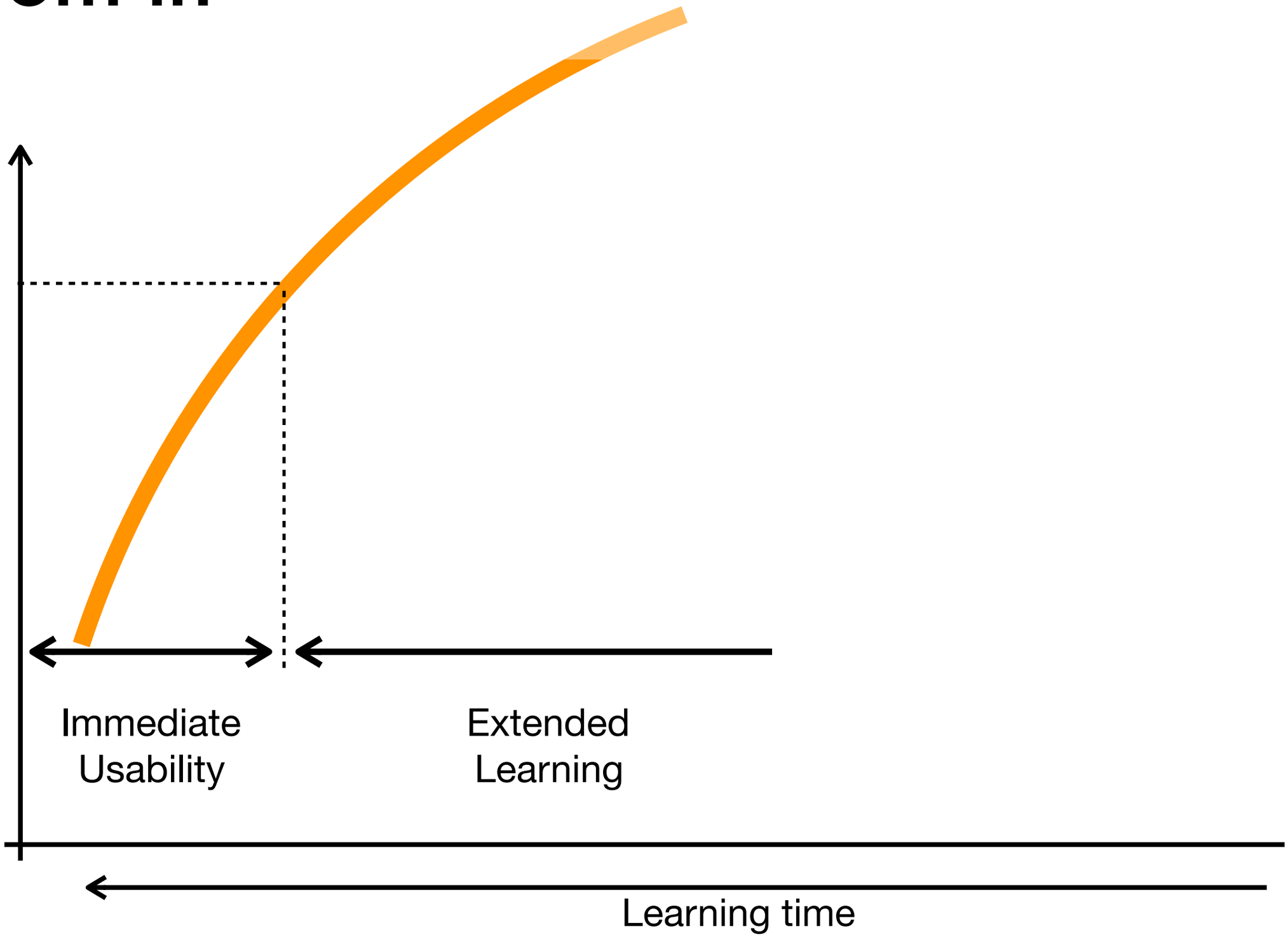
Learning curve



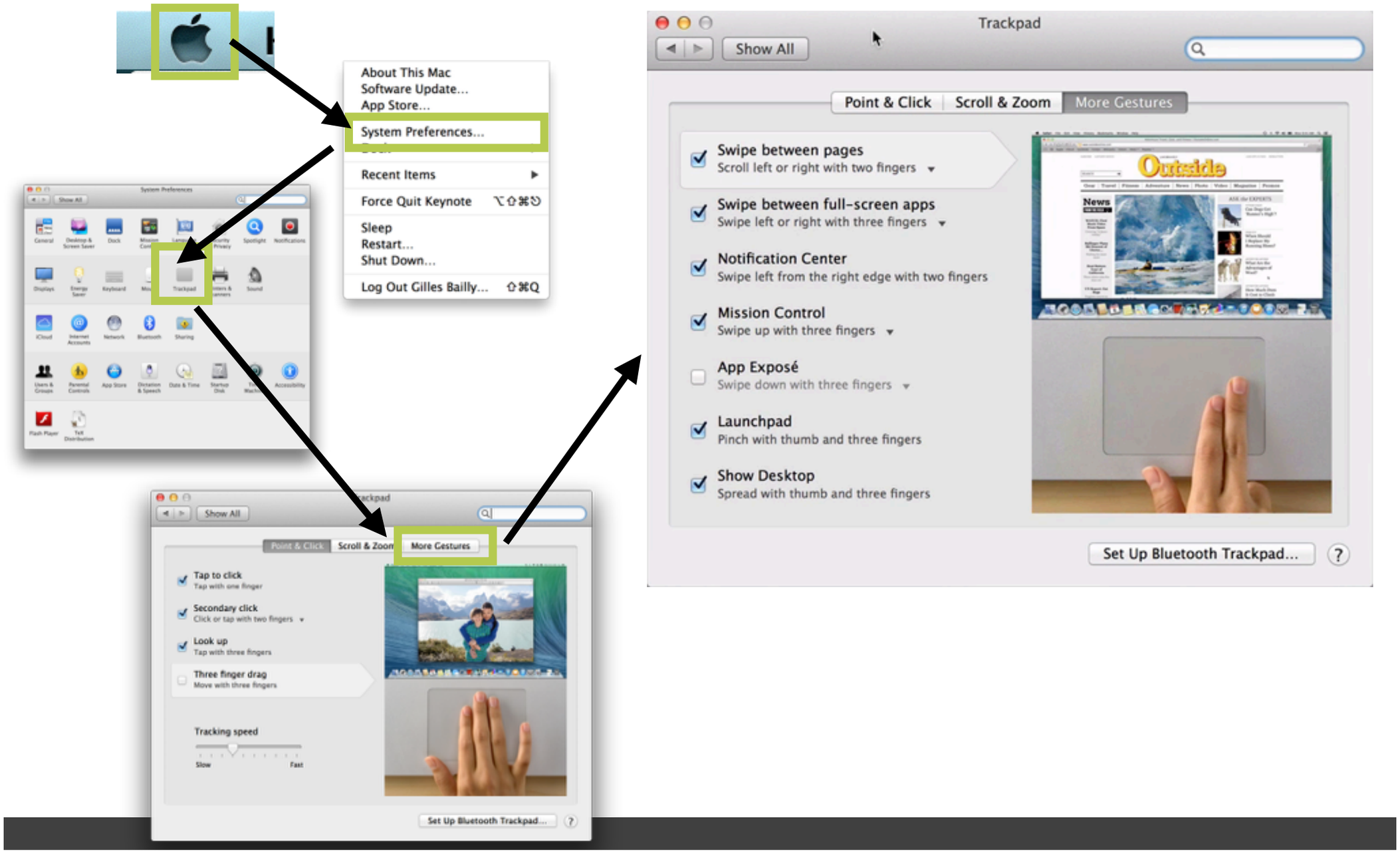
Criteria?


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

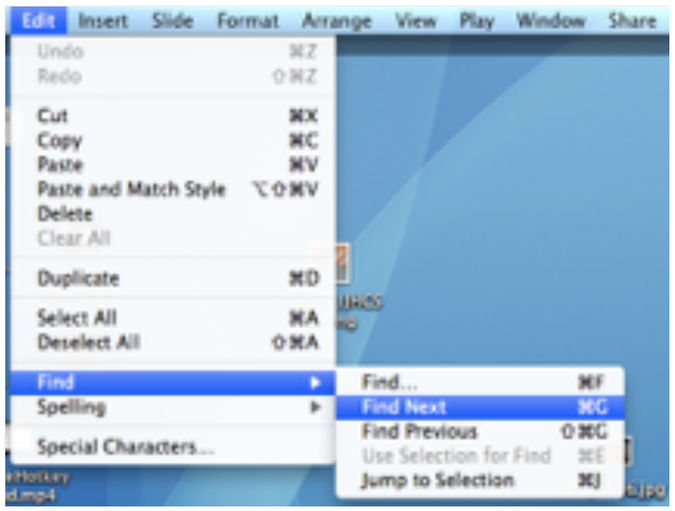
Zoom in



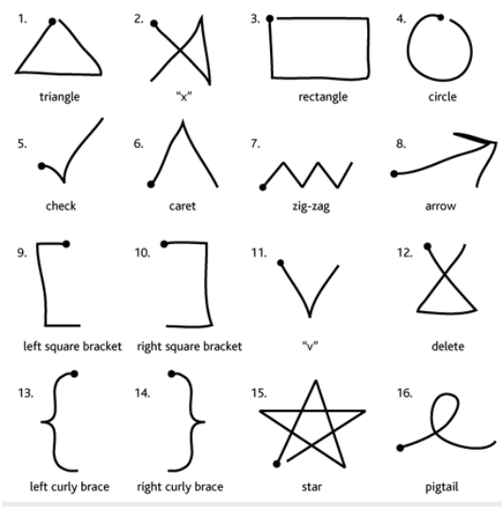
Learning technique 1: Cheat sheet



The case of two modalities



1st modality: menu

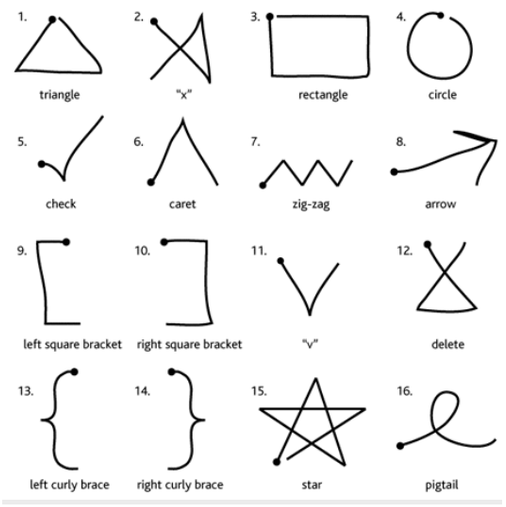


2nd modality: gesture

The case of two modalities

Level of learning

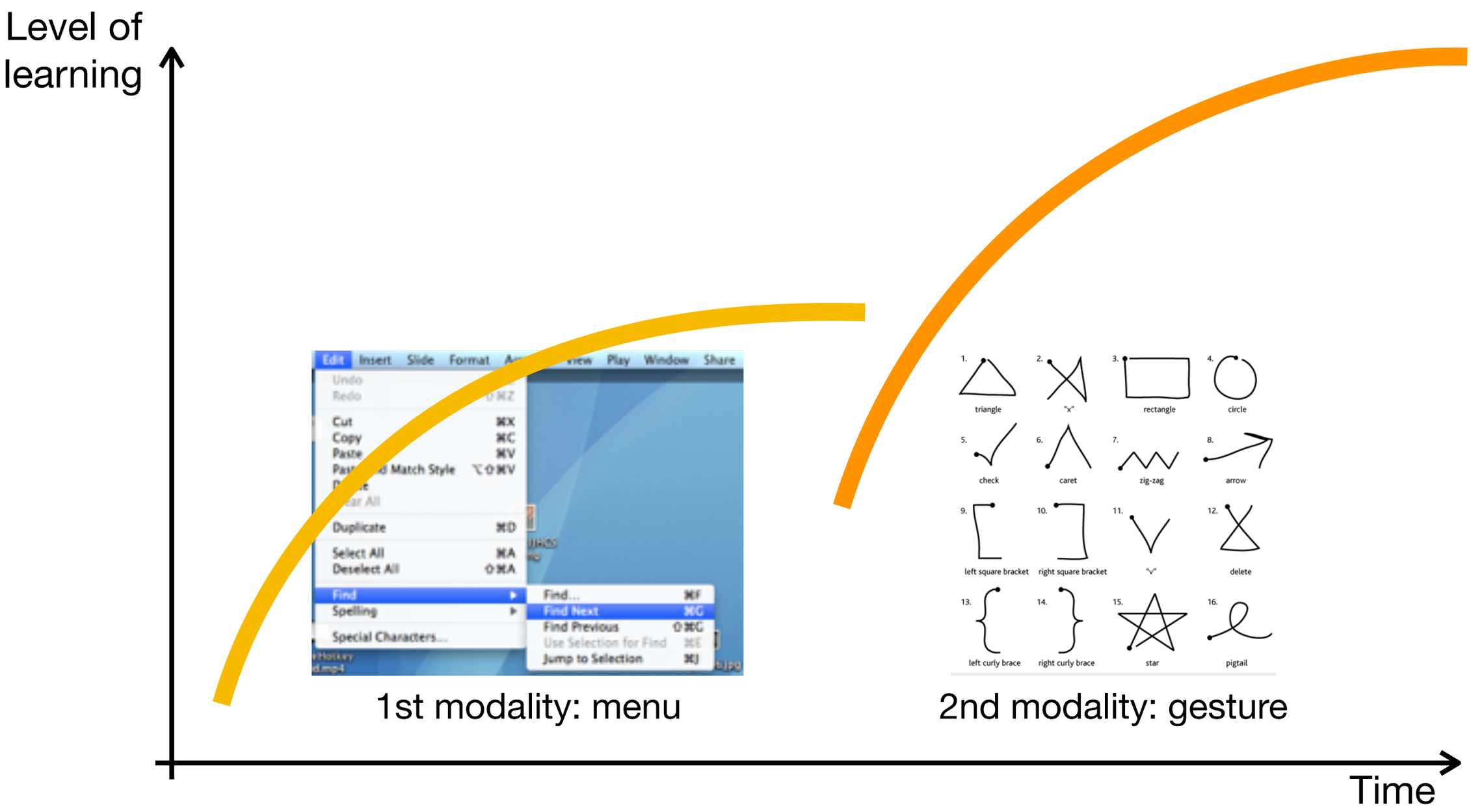
1st modality: menu



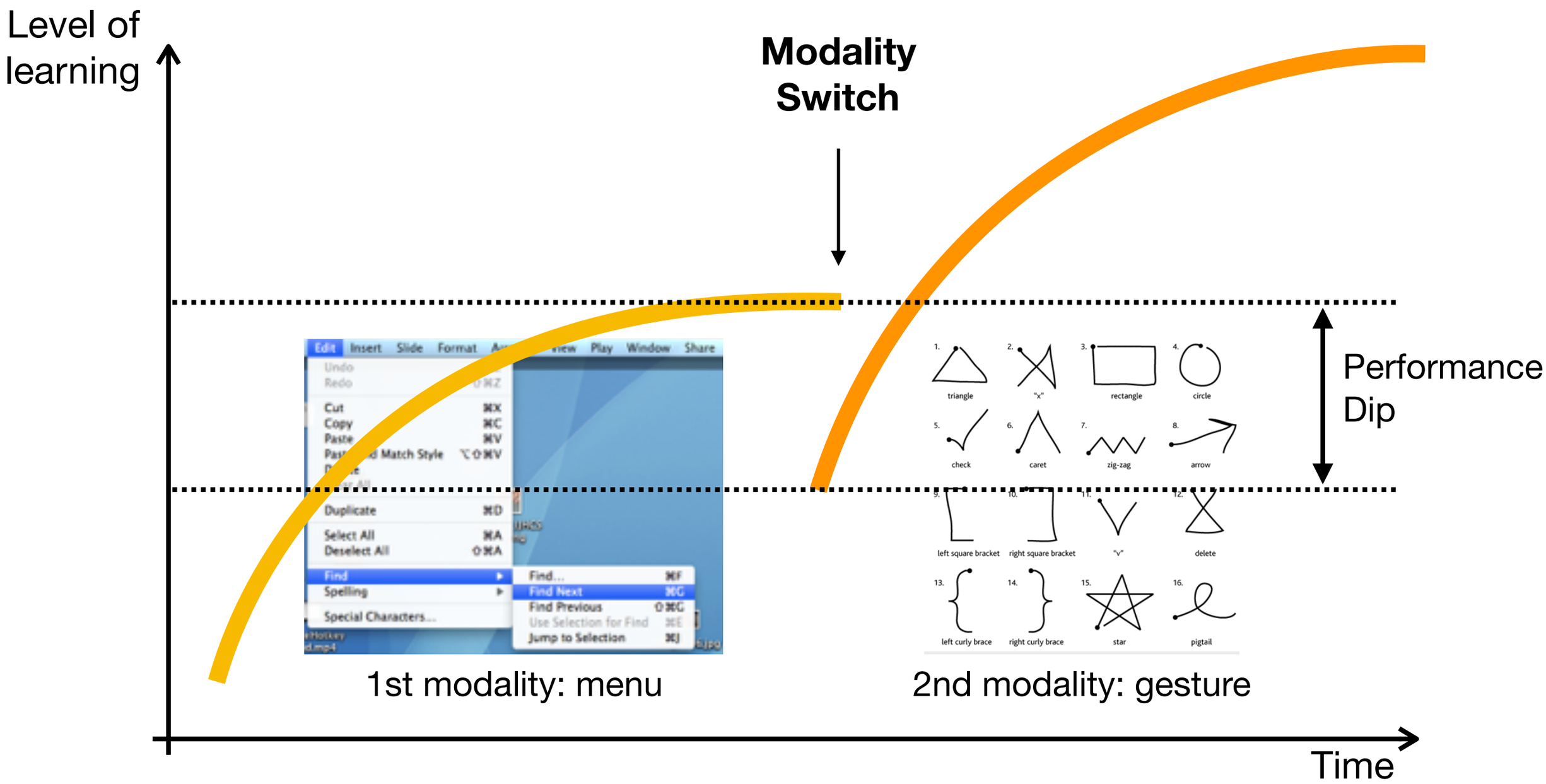
2nd modality: gesture

Time

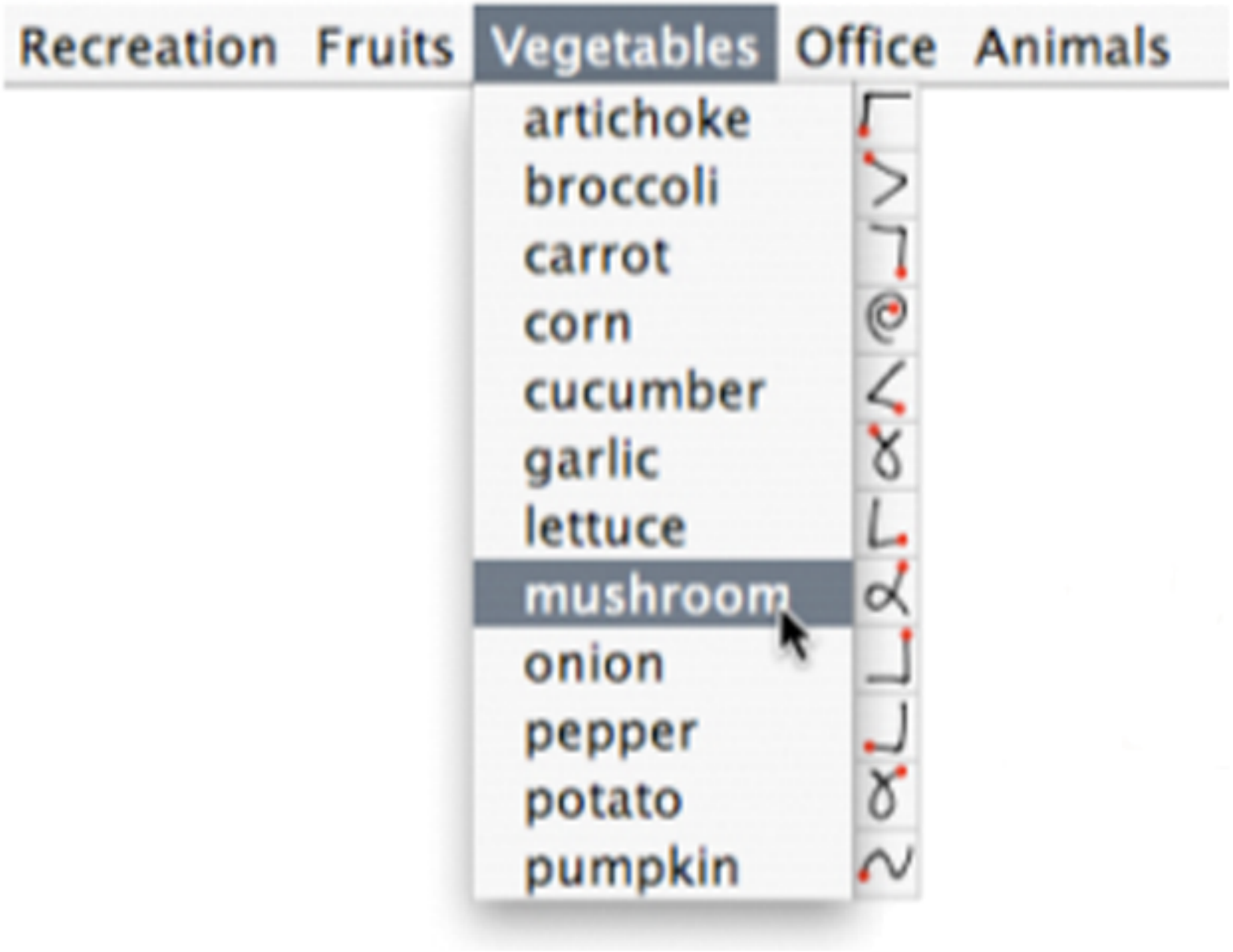
The case of two modalities



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

Recognition accuracy: How many times the system the recognise the correct gestures?

Recognizer evaluation

Recognition accuracy: How many times the system the recognise the correct gestures?

Gesture Spotting: can your system spot when a gesture starts and stops?

Double Flip [Li 11]

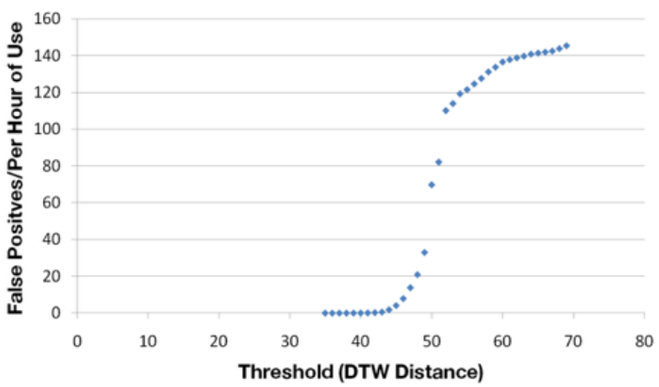


Figure 2: The DoubleFlip false positive rates versus distance threshold level.

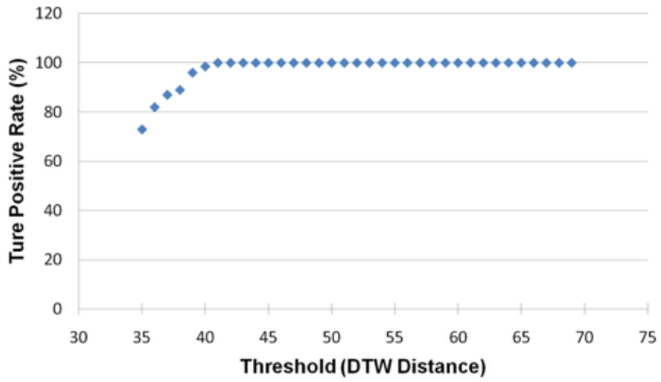


Figure 3: The DoubleFlip true positive rate versus distance threshold level.

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

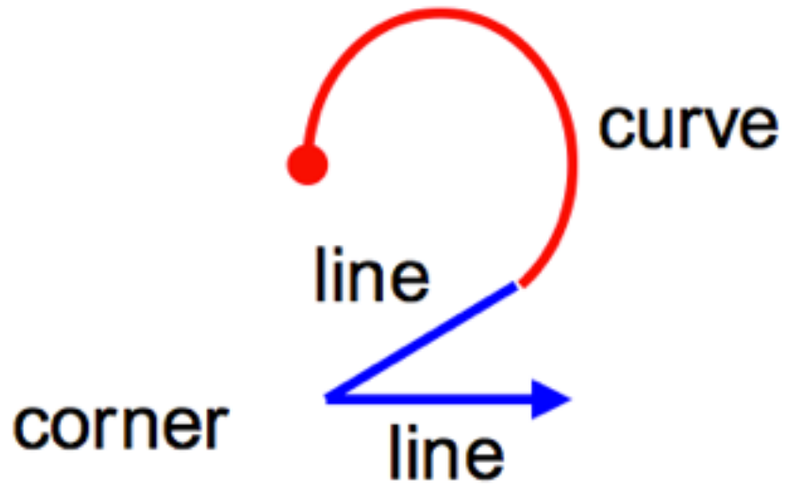
Motor control: model of performance

Gesture characteristics impact gesture timing

Motor control: model of performance

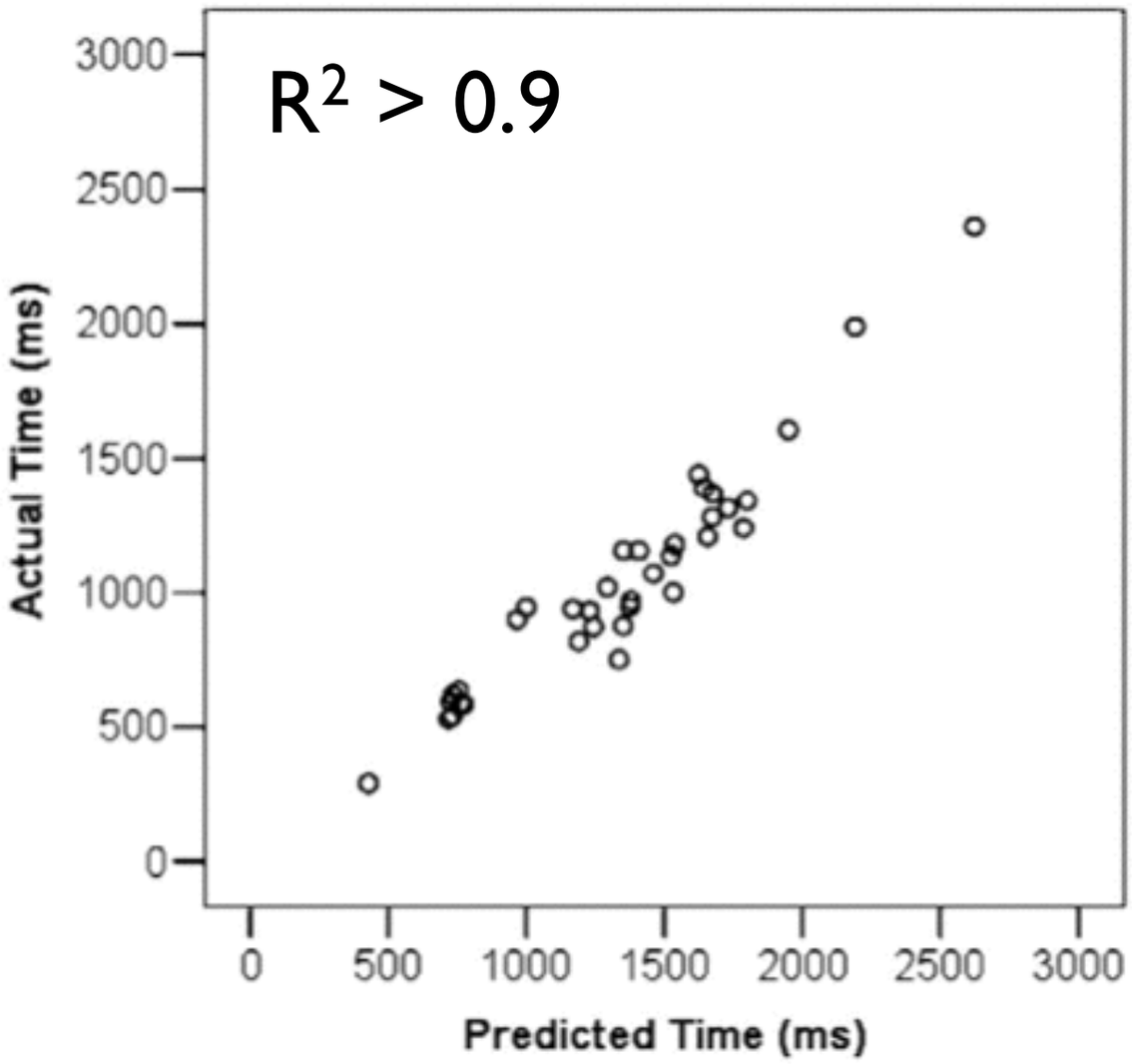
Gesture characteristics impact gesture timing

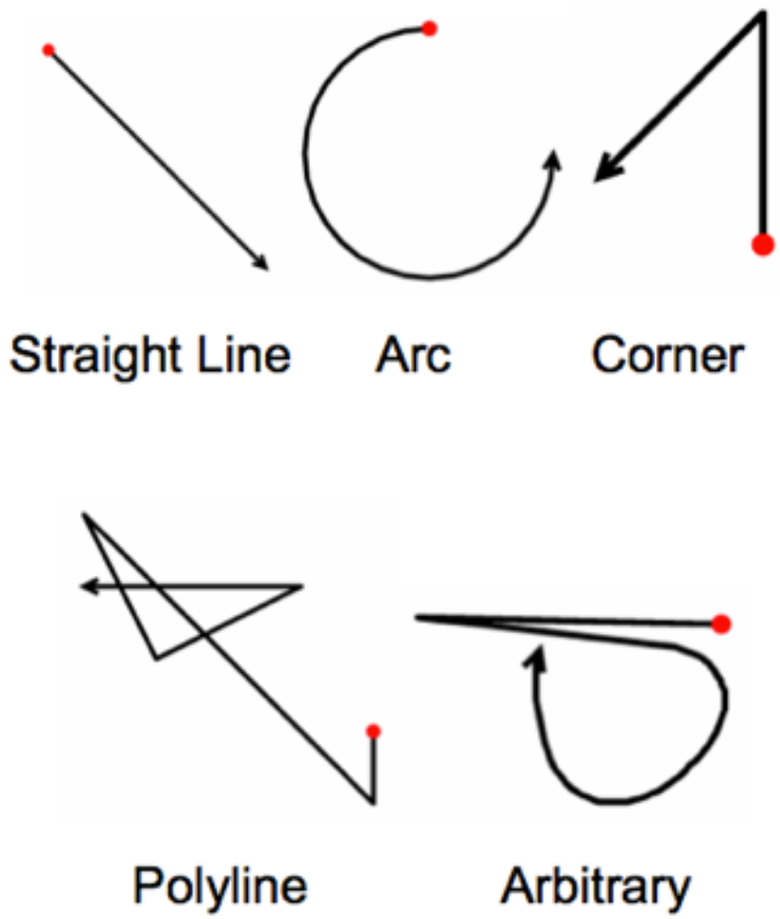
$$T = \sum T(\text{line}) + \sum T(\text{corner}) + \sum T(\text{curve}).$$



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!

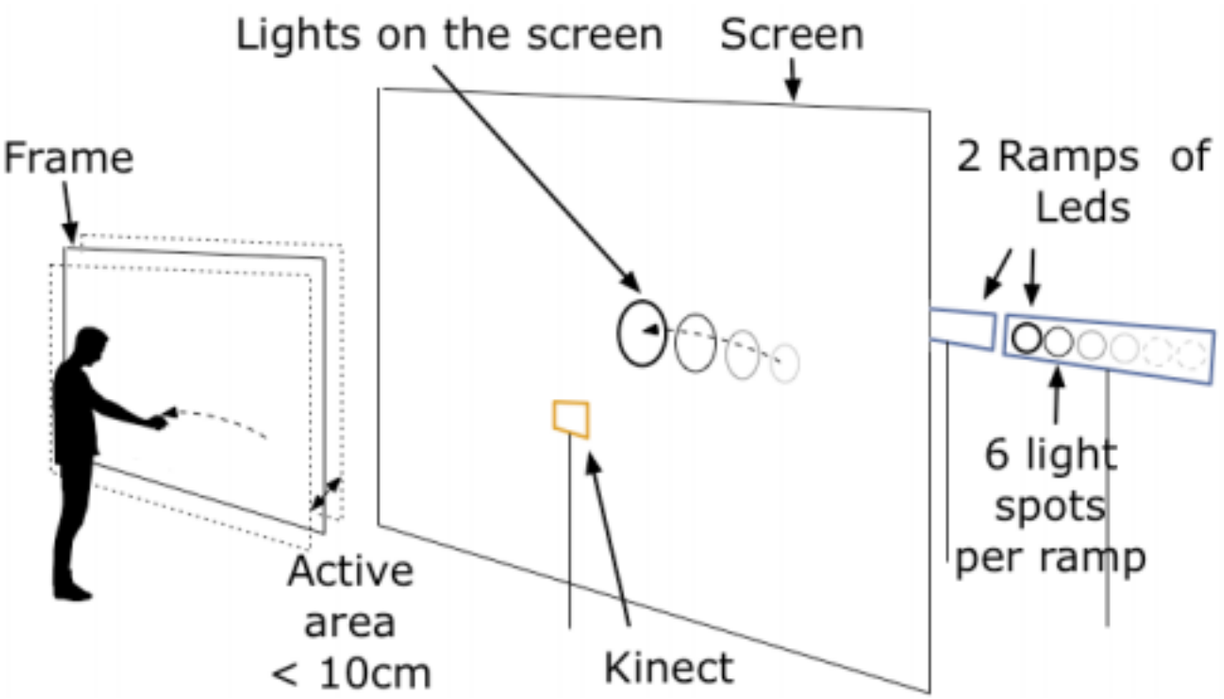
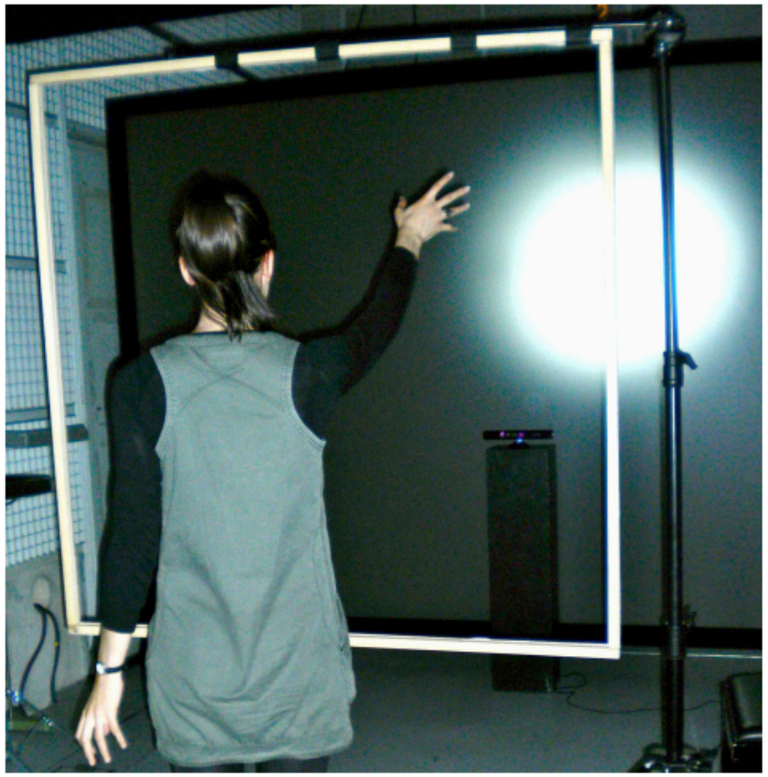


Figure 7. Installation description.



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. Review state of the art
3. Make gestures accessible to novices
4. Make gestures as simple as possible for immediate usability, make gestures learnable otherwise
5. Monitor recognizer accuracy and gesture spotting
6. Make consistent feedback and feedforward processes
7. Assess not only usability, also user experience, attractiveness, expressiveness and skill acquisition