



# Embedded interactive systems

**GIZMO**

2021 DE2-Gizmo (Physical Computing)  
Lecture 5

Dyson School of  
Design Engineering

A/D converter  
sample-and-hold



sensors

(physical)  
environment



display



D/A converter

actuators

Physical  
embodiment

# (Extended) Hardware in the Loop in Cyber-Physical Systems



Traffic light



Silo temperature  
control



Electric orange juicer

Similarities and differences?

A/D converter  
sample-and-hold



display



D/A converter



actuators

sensors



Embedded  
interactive system



Physical  
embodiment

(Extended) Hardware in the  
Loop in Physical Computing



Hardware and Human in  
the Loop

# Interaction

- An occasion when two or more people or things communicate with or react to each other (Cambridge Dictionary)
- A kind of action that occurs as two or more objects have an effect upon one another (Wikipedia)
- Focus on human-tool interaction

A tool addresses human needs by amplifying human capabilities (Bret Victor)

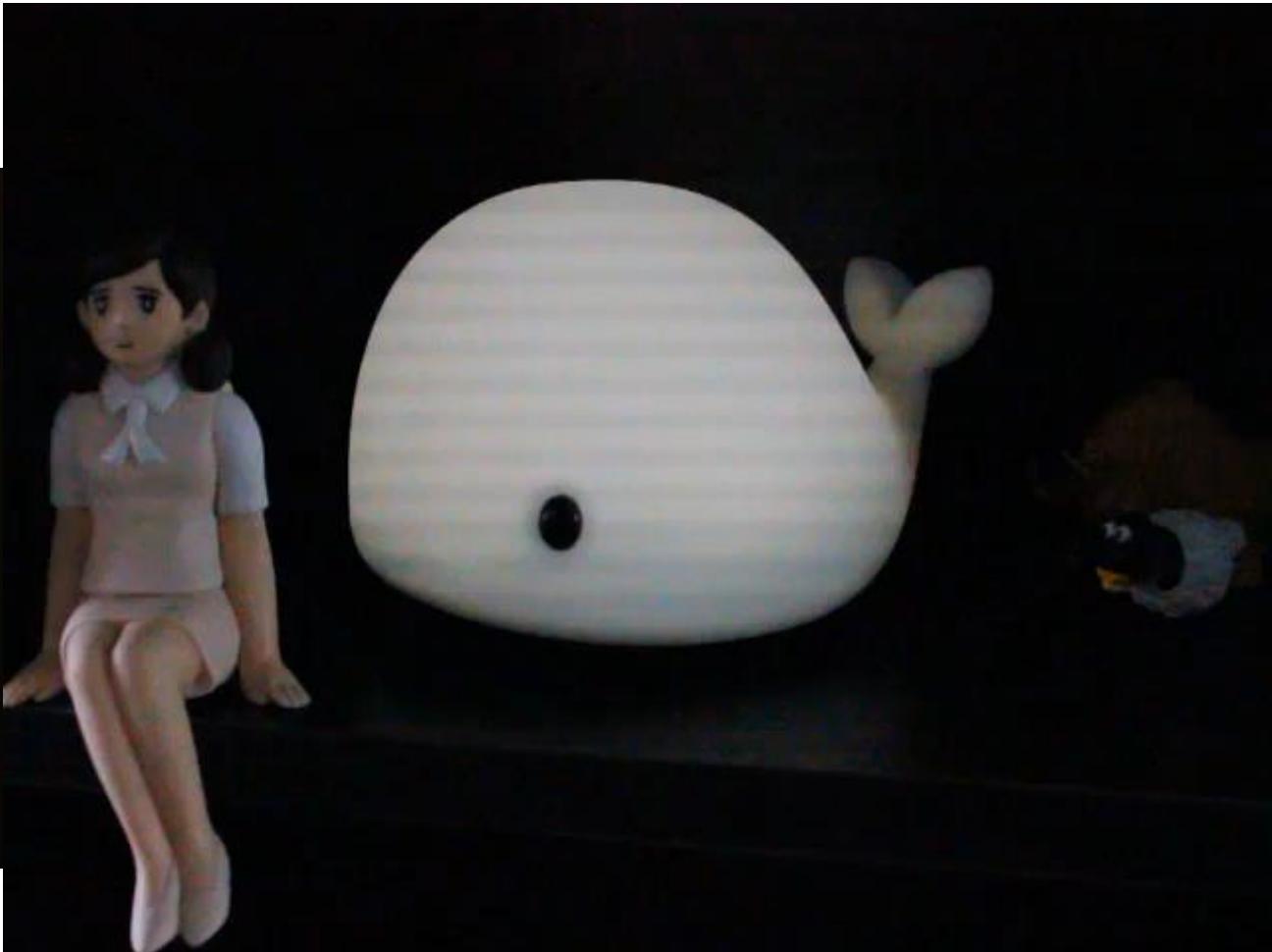


# Interaction

Two lamps

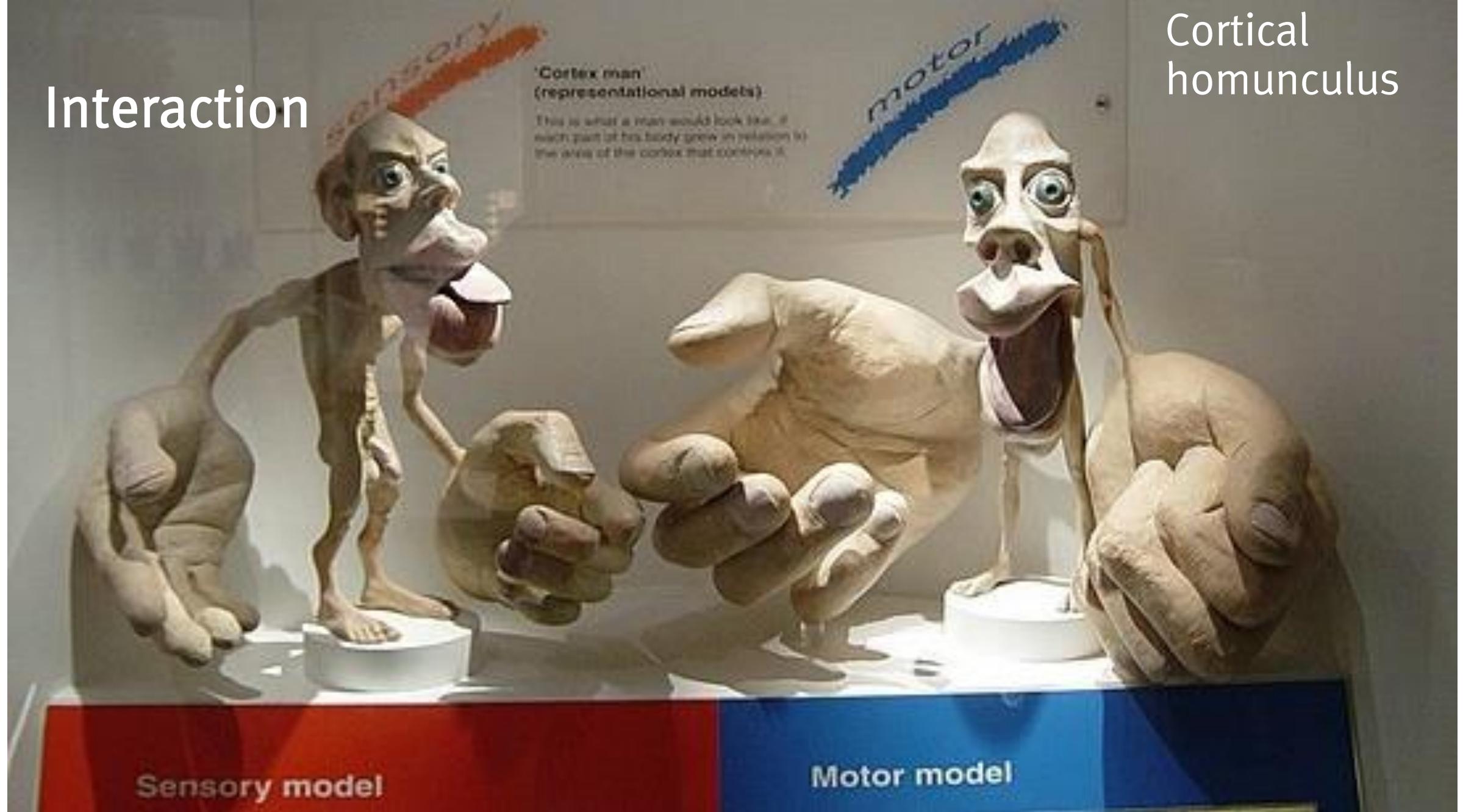


[Lamp 1](#)



[Lamp 2](#)

# Interaction



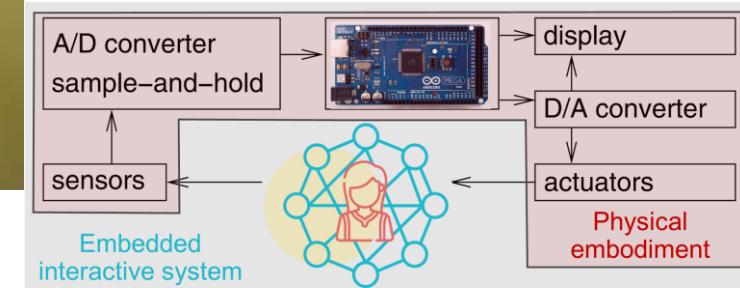
Cortical  
homunculus

# Interaction

The power of  
your hands:  
*feel and  
manipulate  
things*

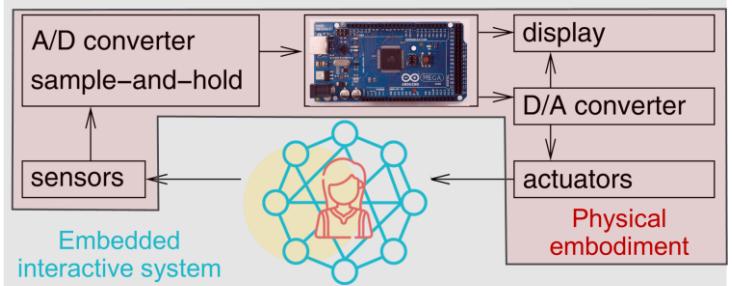


The power of your hands

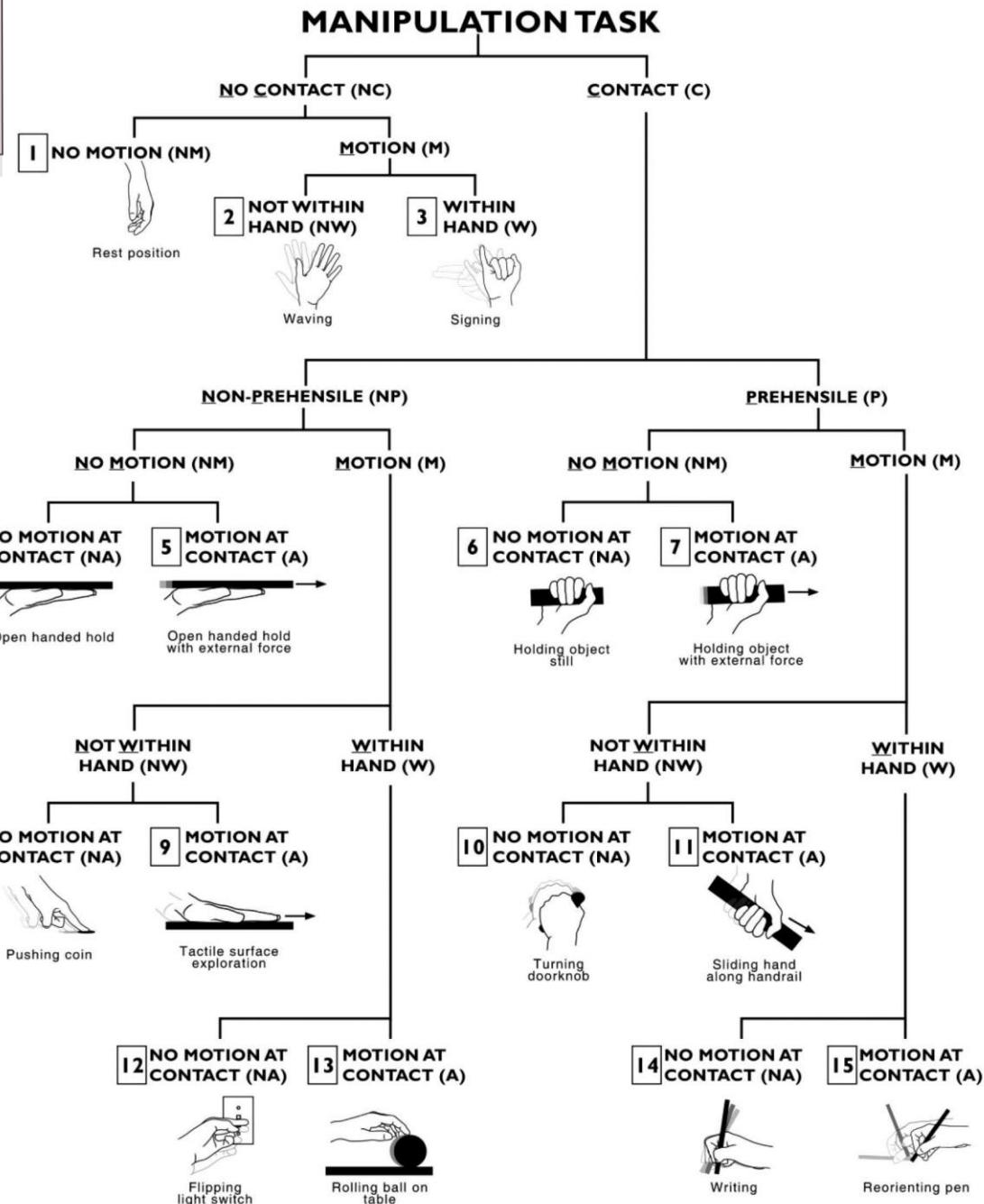


# Interaction

# Grasping and manipulation taxonomies



Opp: VF:	Power					Intermediate				Precision									
	Palm		Pad			Side		Pad			Side								
	3-5	2-5	2	2-3	2-4	2-5	2	3	3-4	2	2-3	2-4	2-5	3					
Thumb Abducted	1: Large Diameter 	2: Small Diameter 	31: Ring 	28: Sphere Finger 	3: Medium Wrap 	18: Extension Type 	26: Sphere 4-Finger 	19: Distal Type 	23: Adduction Grip 	21: Tripod Variation 	9: Palmar Pinch 	24: Tip Pinch 	14: Tripod 	27: Quadpod 	7: Prismatic 2 Finger 	6: Prismatic 3 Finger 	12: Precision Disk 	13: Precision Sphere 	20: Writing Tripod 
Thumb Adducted	17: Index Finger Extension 	4: Adducted Thumb 	5: Light Tool 	16: Lateral 	29: Stick 	15: Fixed Hook 	25: Lateral Tripod 	32: Ventral 	22: Parallel Extension 	Thumb Abducted	Thumb Adducted								





## Bad Designs

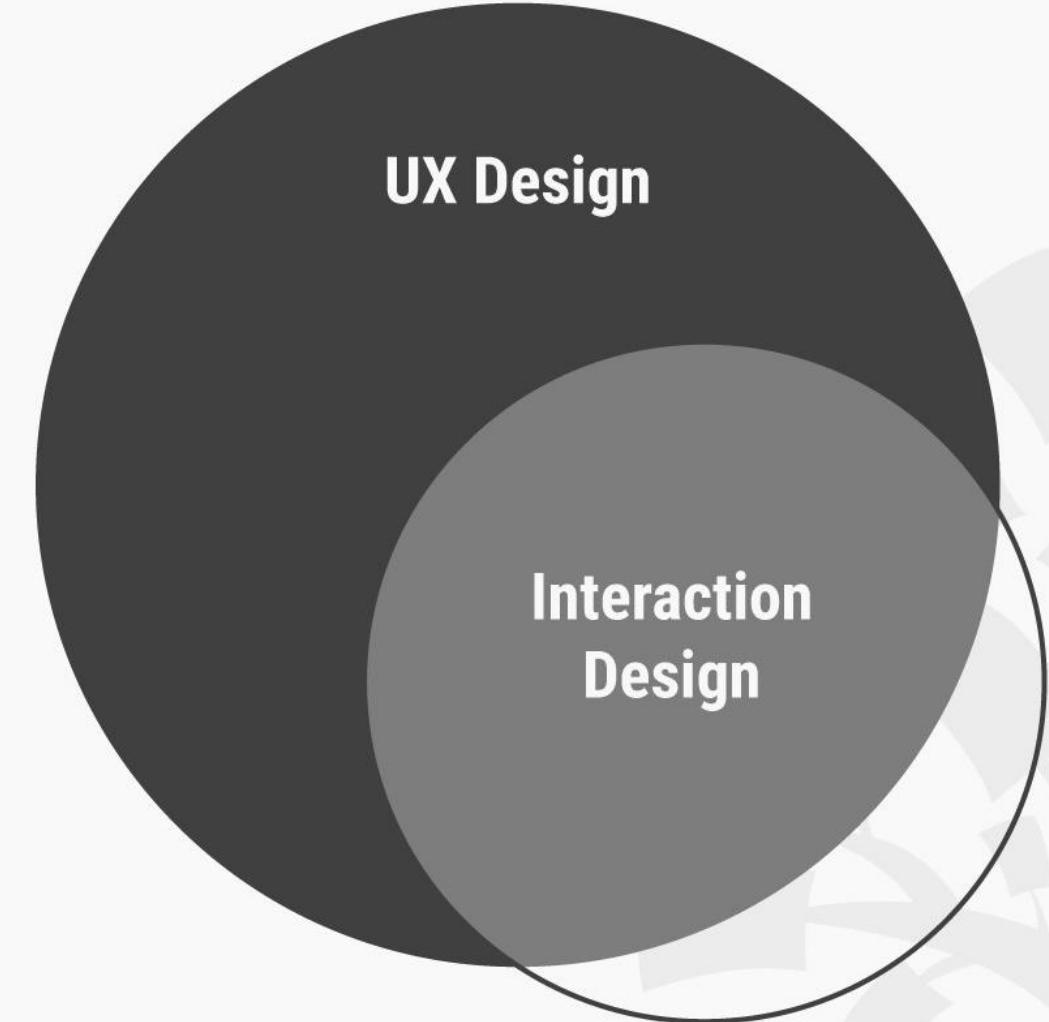
Designing interactive products requires considering who is going to be using them, how they are going to be used, and where they are going to be used



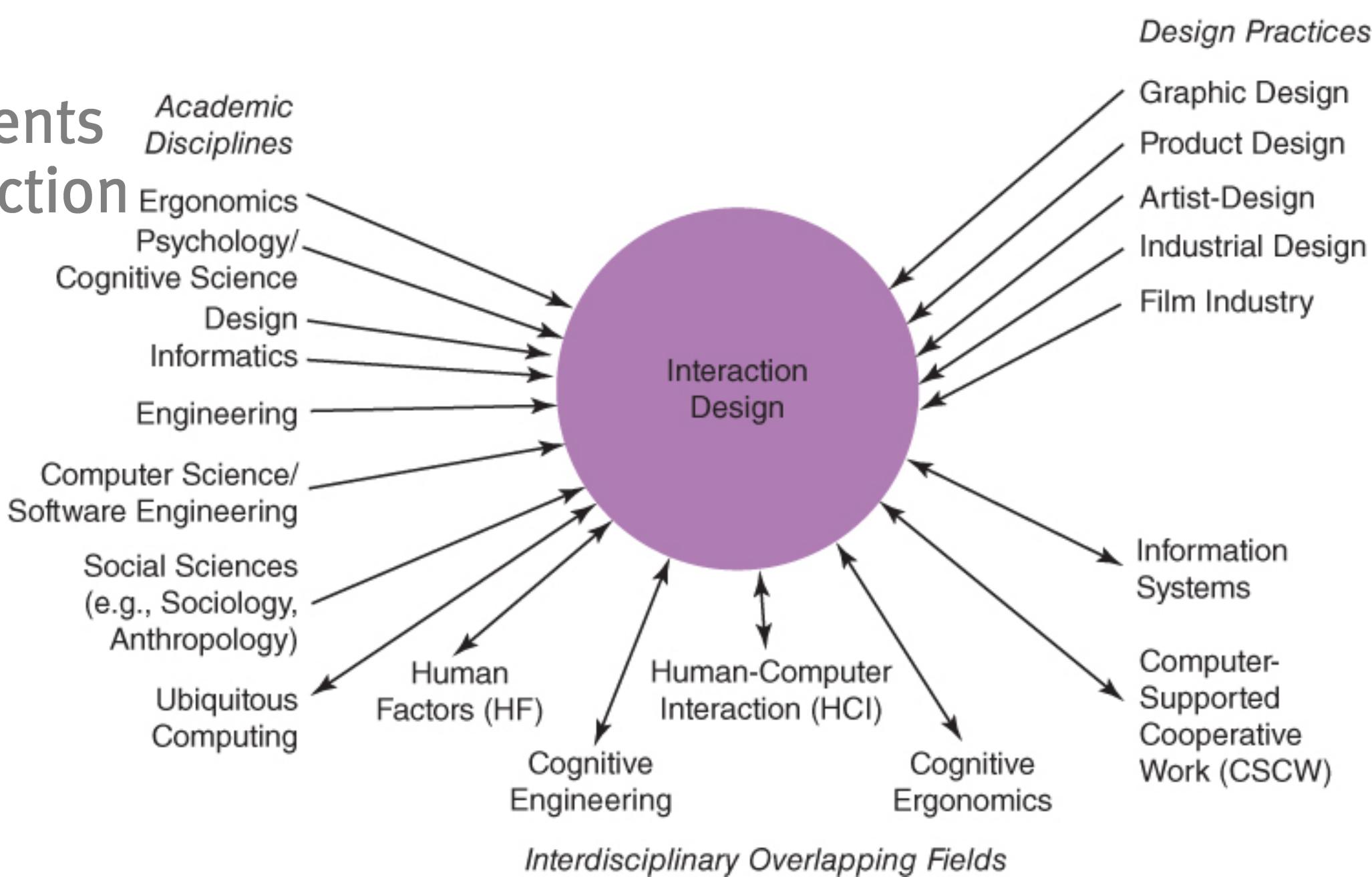
## Interaction Design: A Part of UX Design

# Interaction Design

Interaction Design (IxD) is the design of interactive products and services in which a designer's focus goes beyond the item in development to include the way users will interact with it. Thus, close scrutiny of users' needs, limitations and contexts, etc. empowers designers to customize output to suit precise demands (Interaction Design Foundation)

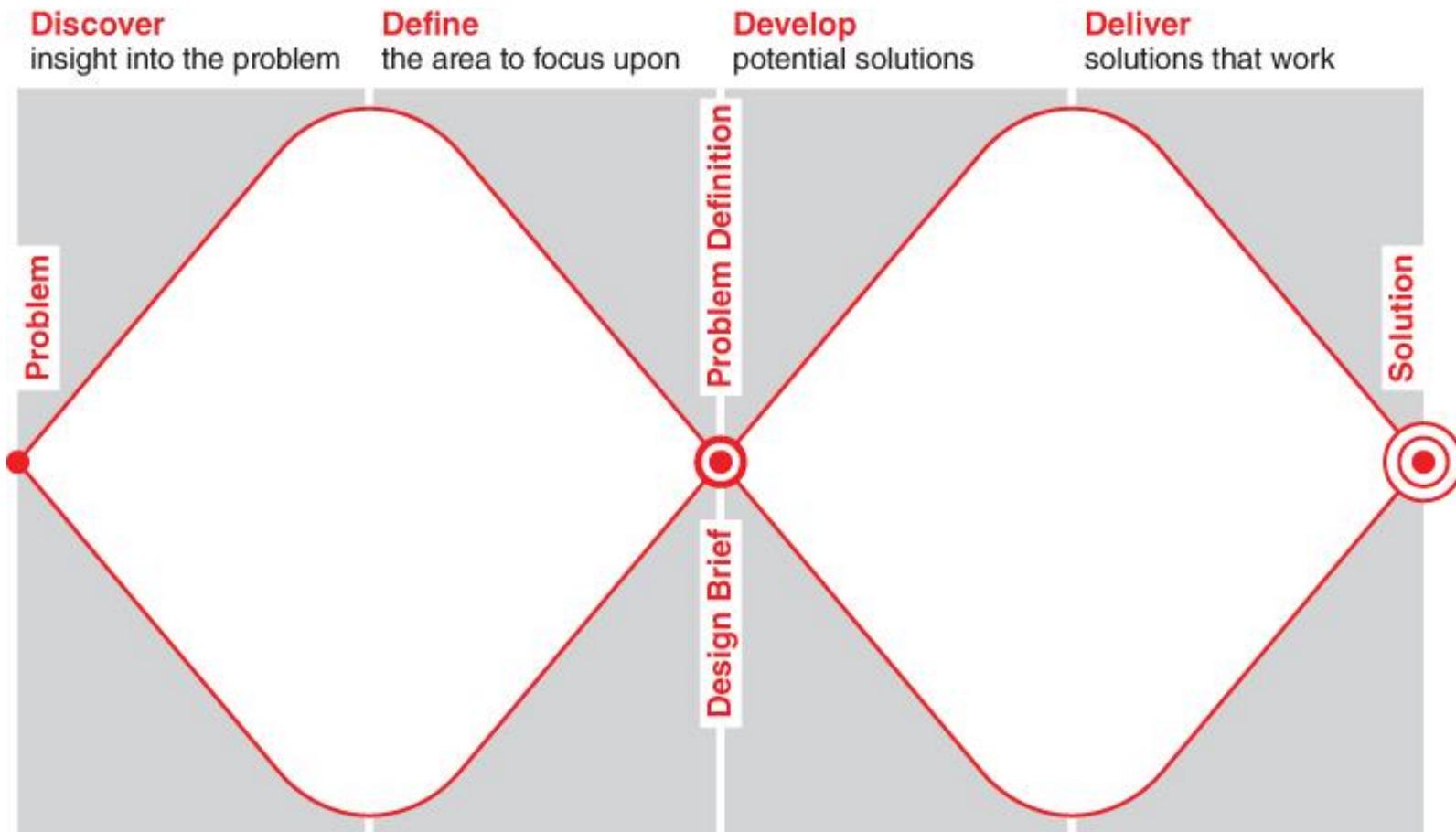


# The Components of Interaction Design



# Interaction Design

Interaction design also follows the phases of the double-diamond of design



# Approaches to Interaction Design

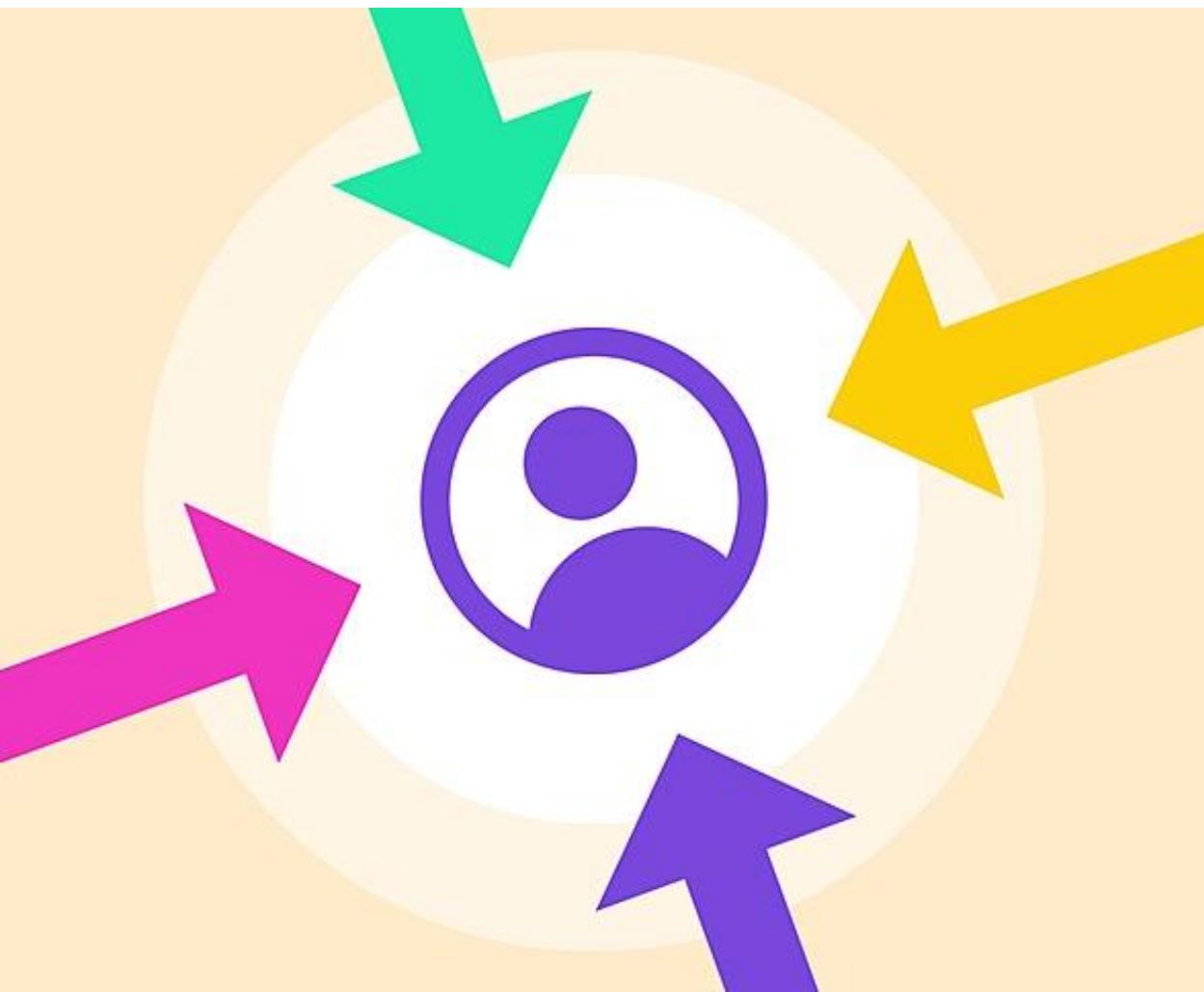
- User-centred design
  - The user knows best and is the guide to the designer
- Activity-centred design
  - Focuses on the behaviour surrounding particular tasks
- Systems design
  - Holistic design approach that focuses on context
- Genius design
  - Relies largely on the experience and creative flair of a designer



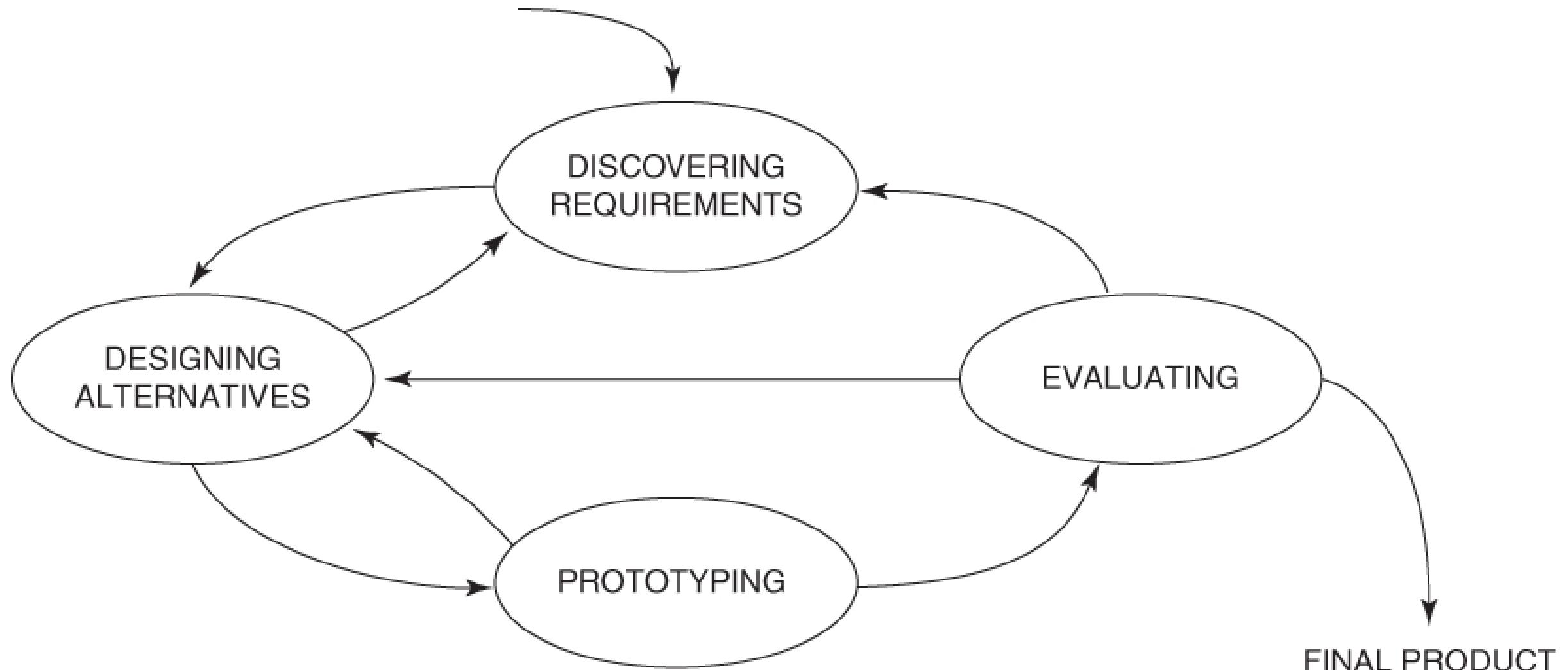
# User-Centred Approach

## Principles

- Early focus on users and tasks
- Empirical measurement
- Iterative design



# Interaction Design Lifecycle Model



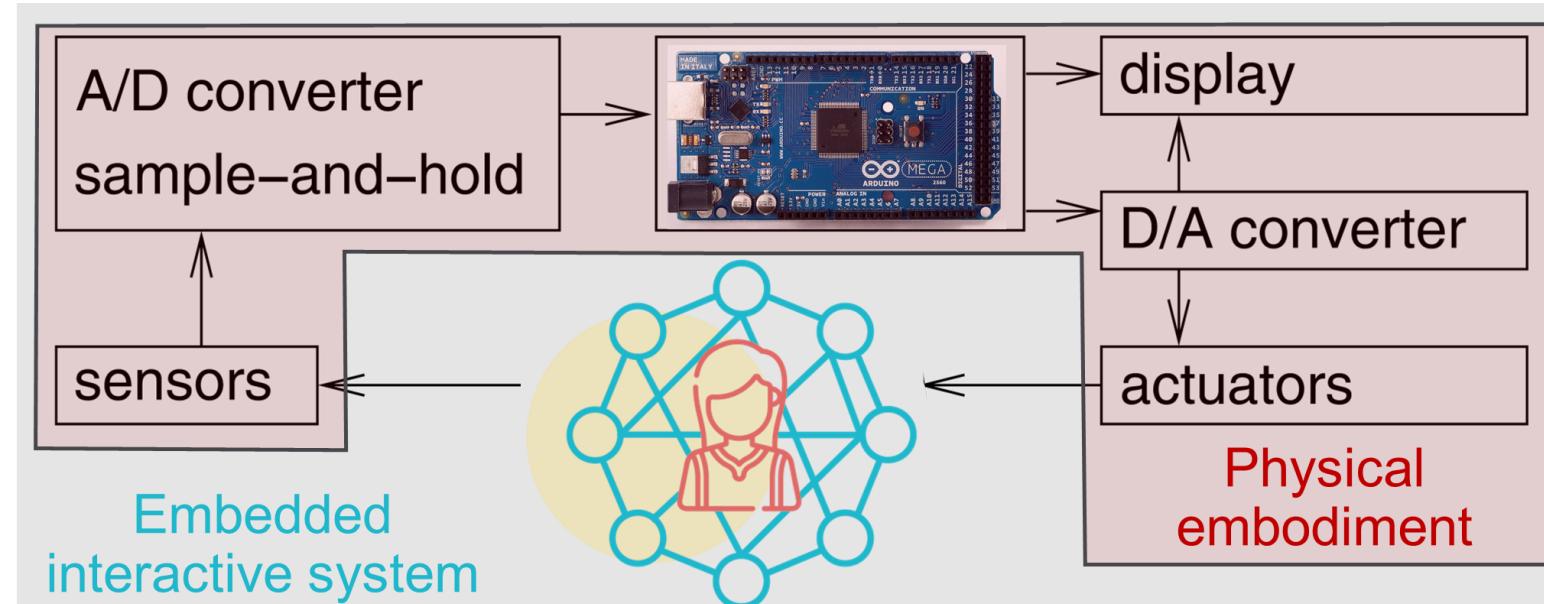
# Embedded Interaction

The technological and conceptual phenomena of seamlessly integrating the means for interaction into everyday artifacts

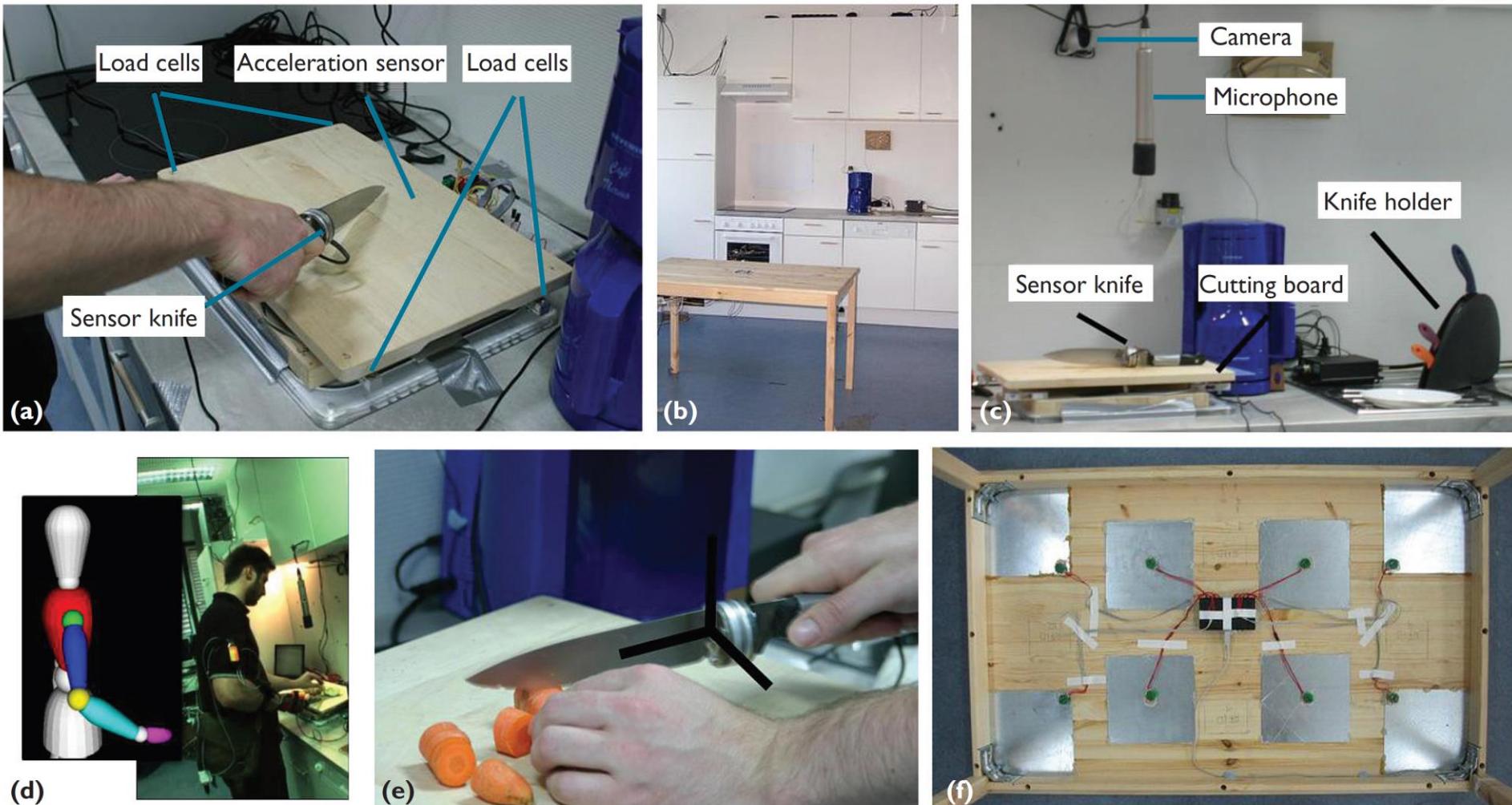
Technically, this requires embedding sensing, actuation, processing, and networking into common objects

Conceptually, it requires embedding interaction into users' everyday tasks

(Kranz, Holleis, and Schmidt, 2010)



# Case Study 1: Context-Aware Kitchen Utilities

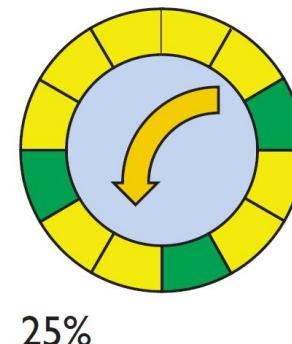
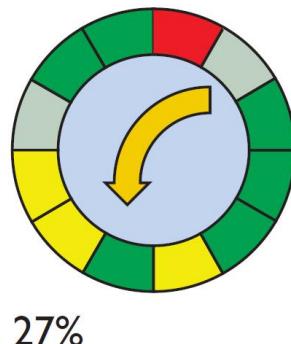
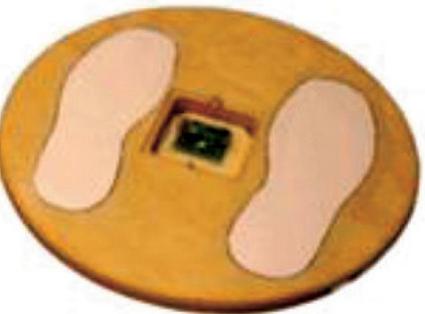
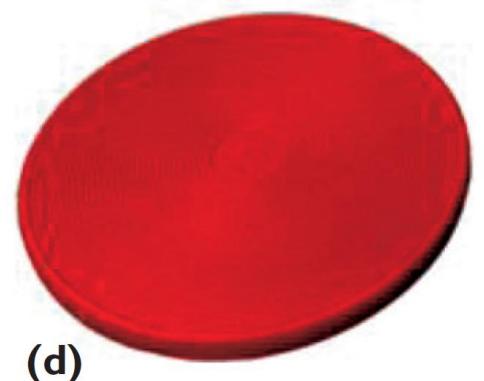
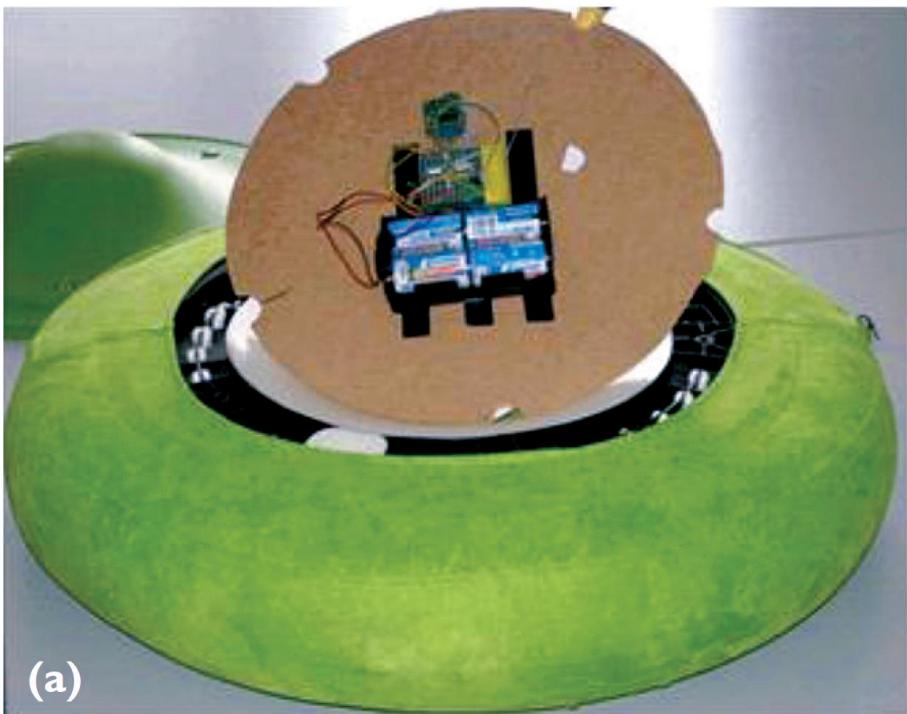


# Case Study 2: Capacitive Touch Input on Clothes



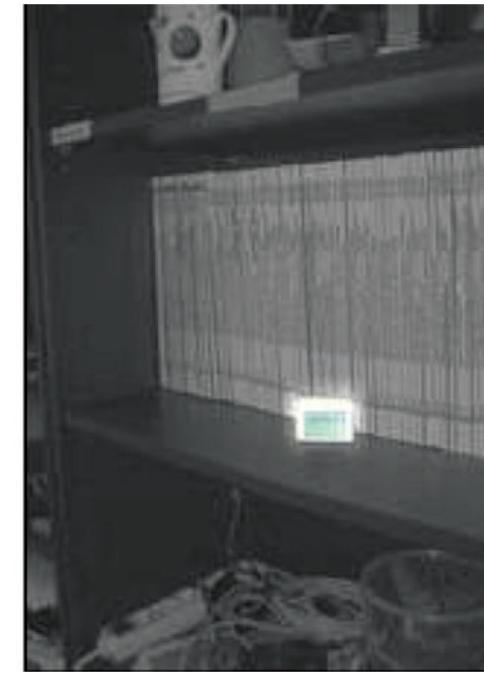
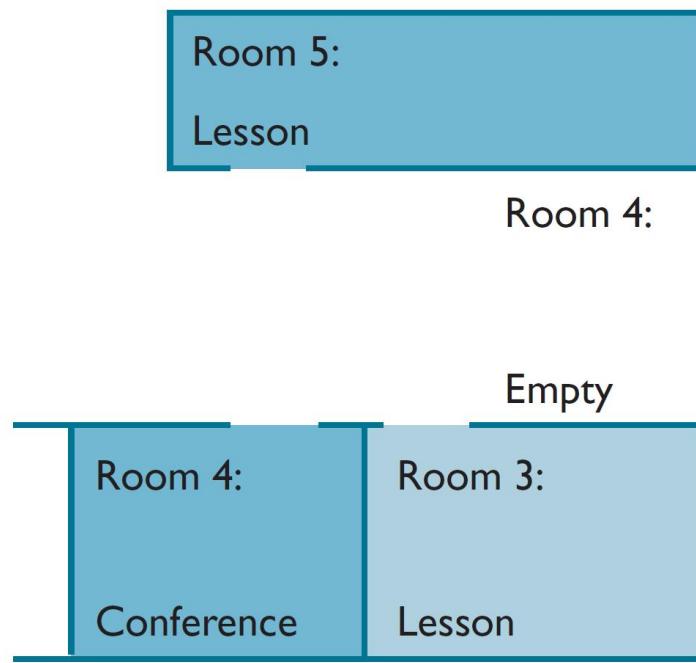
Flexibly soldered sets of touch sensors (QProx QT110) (a) into several device prototypes, including a phone bag (b), bicycle helmet (c), and piece of clothing with different designs for touch areas (d)

# Case Study 3: Entertainment and Sports



(d)

# Case Study 4: Small Embedded Objects



An interactive room information system (a and b) as well as a wireless display that allows gesture input (only) and somewhat fades into the background if not in use (c and d)



# Challenges of Embedded Interaction

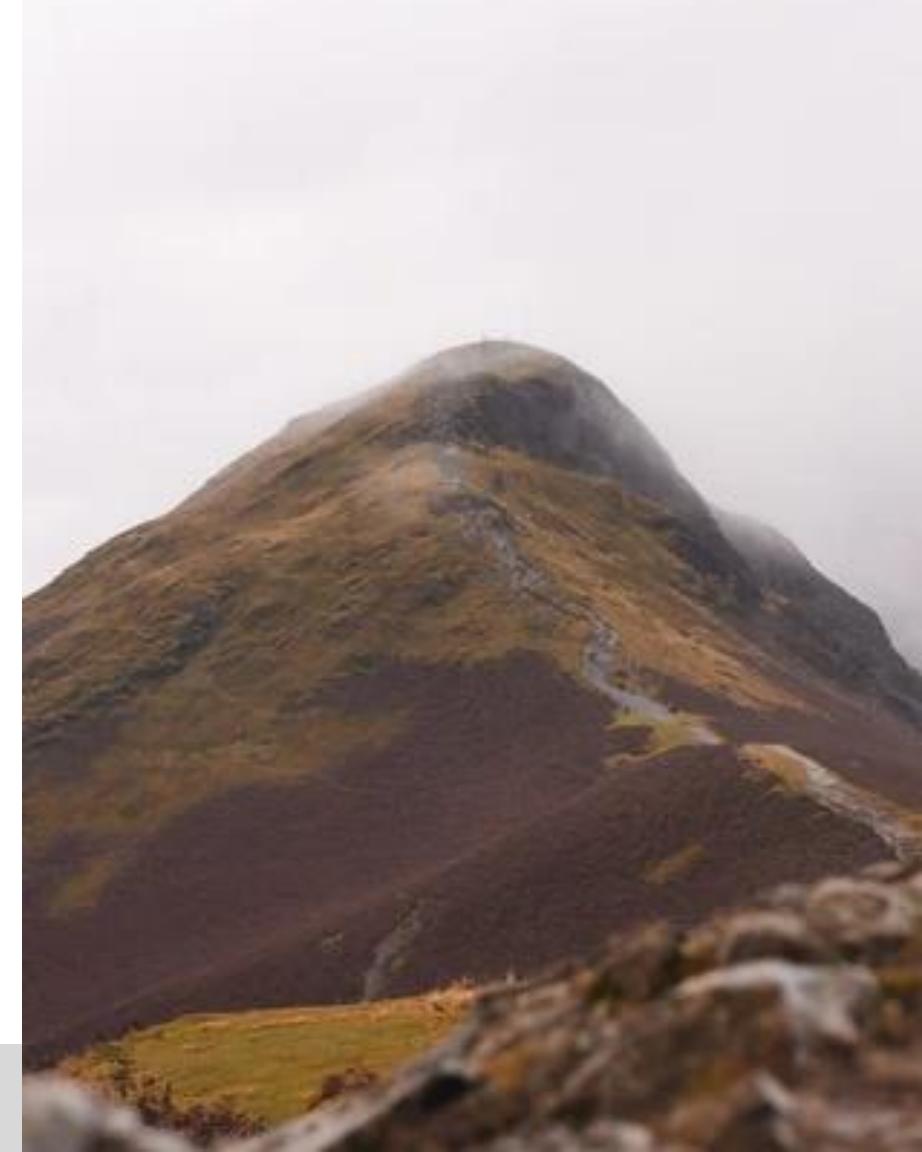
The design of embedded interactive systems poses many challenges to researchers, developers and users

1. Embedded devices vs interaction devices
2. Invisibility dilemma
3. Implicit vs explicit interaction

# Challenges of Embedded Interaction

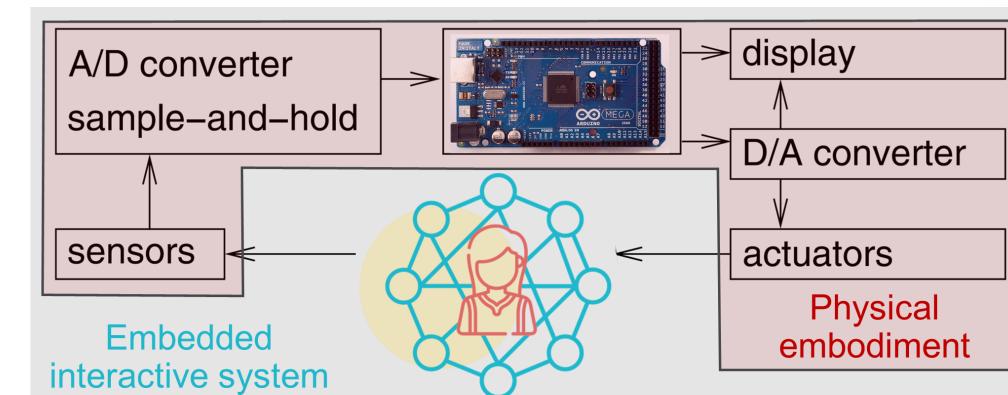
The design of embedded interactive systems poses many challenges to researchers, developers and users

- 4. Context dependence
- 5. Interaction and multimodality
- 6. Development support



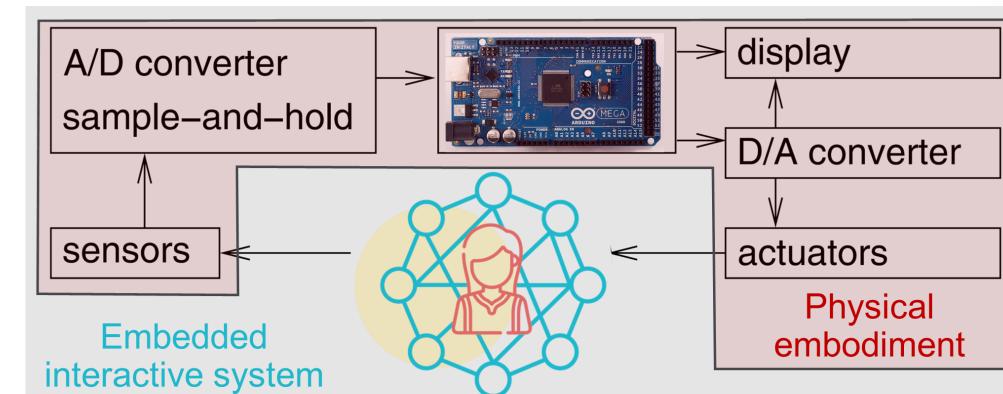
# Design Guidelines for Embedded Interaction

- Information when and where it is useful
- Information provision without explicit interaction
- Overprovisioning
- Specialized components
- Visibility
- Accidental use
- The invisibility dilemma
- Short- and long-term life cycle
- Rapid prototyping
- Modelling support



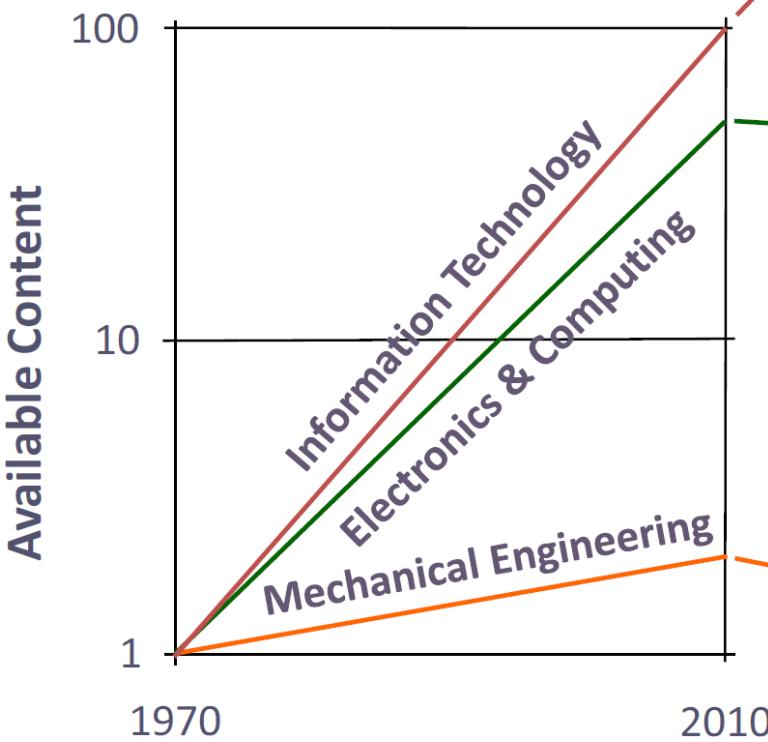
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# Diversification of Core Technologies

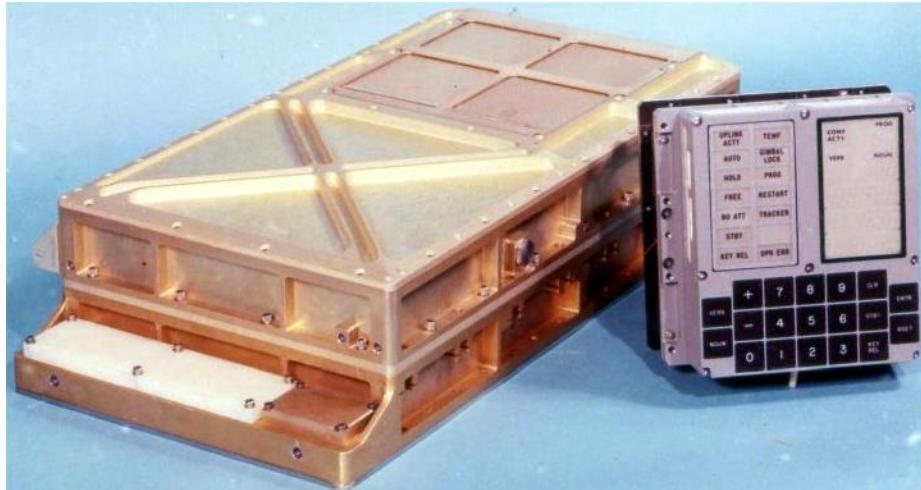
Let's consider the differences between the Apollo Guidance Computer and current tablets



(Bradley et al., 2015)

- Internet of Things
  - Cyber-Physical Systems
  - Applications programming
  - Smart technologies
  - Artificial intelligence
  - MEMS technologies
  - Advanced HMI
  - Internet
  - Networking & Communications
  - World Wide Web
- 
- Multi-core processors
  - Flexible circuit boards
  - Sensor technologies
  - MEMS technologies
  - Networking
  - Communications
  - High capacity memory
  - Graphics
- 
- Materials
  - Simulation & Modelling
  - Computational Fluid Dynamics
  - MEMS technologies
  - Control
  - Robotics
  - 3D printing

# Diversification of Core Technologies



Apollo Guidance Computer  
(1966)

What about differences in interaction?



iPad Air (2019)

# The Future of Interaction

Technologies for implicit and explicit interaction expected to be ubiquitous by 2032 (Schmidt et al, 2012)

- Pico projectors
- Digital signage and public displays
- Spatial gestural interaction
- Brain-computer interfaces
- Physiological (self-)monitoring
- Continuous capture and extended human memory





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Design Engineering