POLITECNICO
MILANO 1863

IMAGE AND SOUND
ISPG
PROCESSING GROUP

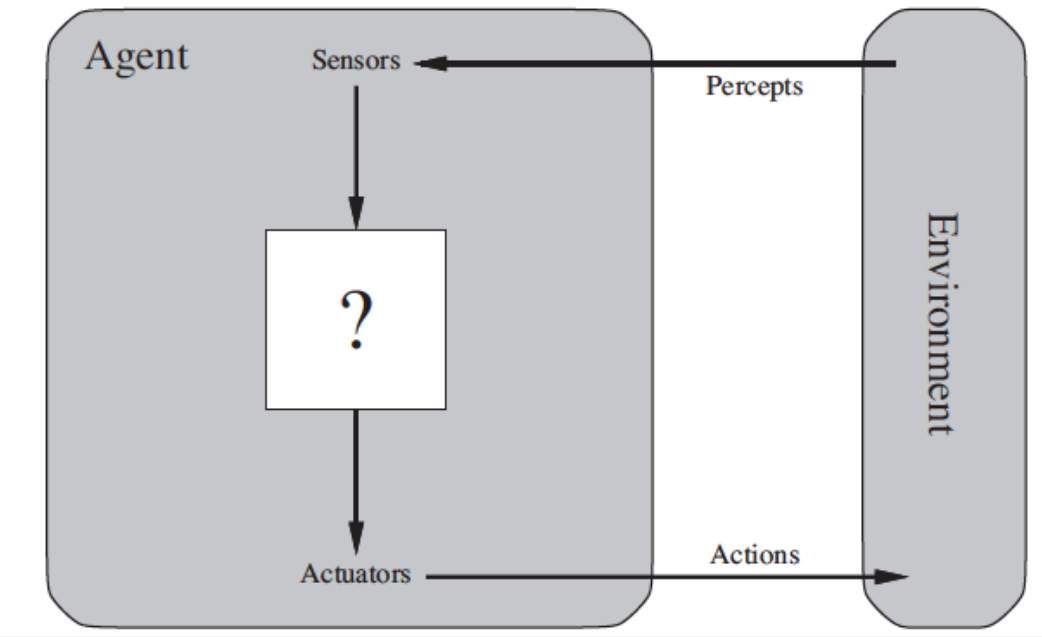
CREATIVE PROGRAMMING AND COMPUTING

The world described through data and signals

AGENTS

- As mentioned before Creative Computing deals with *tools* and *algorithms*
- In this course we use *agents* to formally describe *algorithms*

An agent is anything that can be viewed as perceiving its **ENVIRONMENT** through sensors and acting upon that environment through **ACTUATORS**



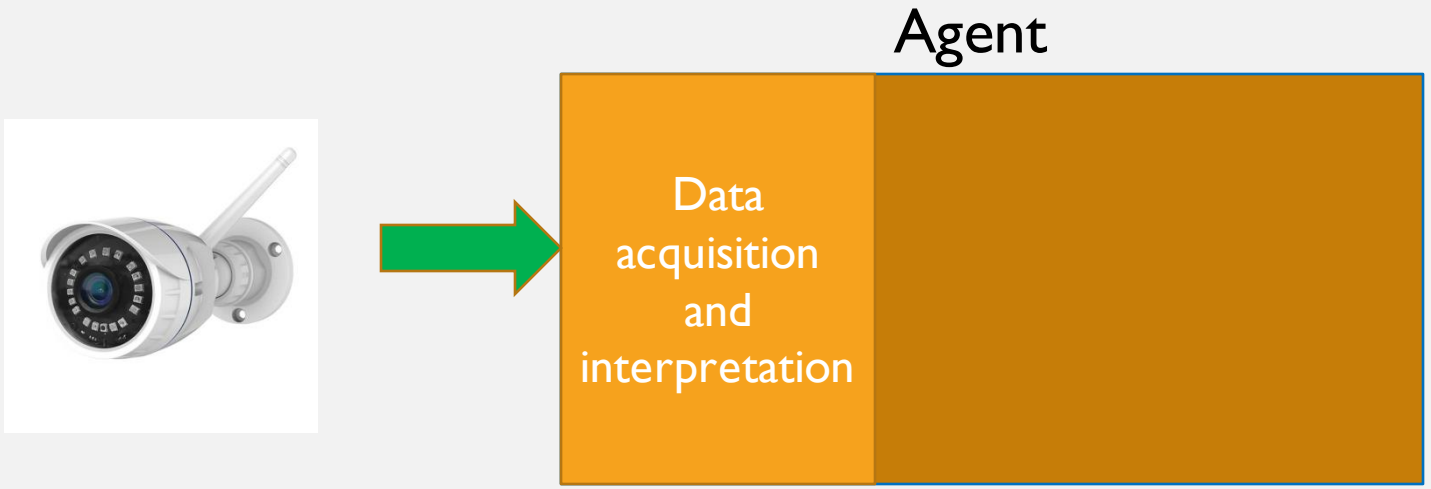
AGENTS

- Agent's behaviour is described by the **AGENT FUNCTION** that maps any given percept sequence to an action

- The environment can be the physical real world or a virtual world (other agents)
- There are different opinions about the grade of interaction between the agent and environment. Here we adopt the most wide one:
  - An algorithm is defined an agent even if does not perceive the environment (no input)
    - Example: grammar-based agents for automatic music composition
    - They can have a set of rules and they produces some action independently by the input
    - They "just do it"
  - An algorithm cannot be defined as agent if it doesn't perform an action that affect the environment

PERCEPTION

- Perception refers to how information is acquired from the environment via the different sense organs – eyes, ears, fingers – and transformed into experiences of objects, events, sounds, and tastes
- With respect to agents design it is important to present information in a way that can be readily perceived in the manner intended.



INTERACTION DESIGN

NEW MEDIA ART

- Review of the key elements of new media art:

- **Materiality**: the artist and the audience are engaged with the physical world
- **Embodiment**: being in the world in which the mind and the body are not constructed as separated in independent entities
- **The Cyborg**: the artistic piece should exabits a certain degree of autonomy
- **Hybridity**: hybridity of disciplines and of the real world with the virtual world
- **Narrative**: there should be an evolution in time
- **Interactivity**: the viewer as the power to be an active participant in the unfolding of a works' flow of events, influencing and modifying its forms and narratives

NEW MUSICAL INSTRUMENT

- Form the beginning of our history, humans looked for new instruments for artistic production more suitable to express social characteristics of that time

DEFINITION

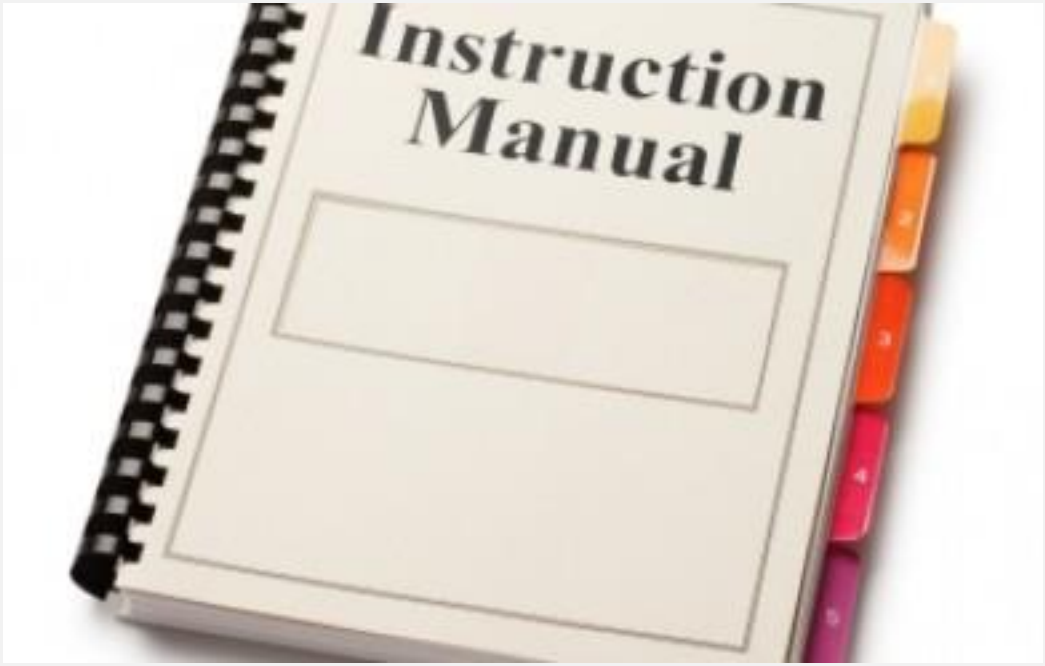
- Computers are everywhere
- We constantly interact with computers

DEFINITION

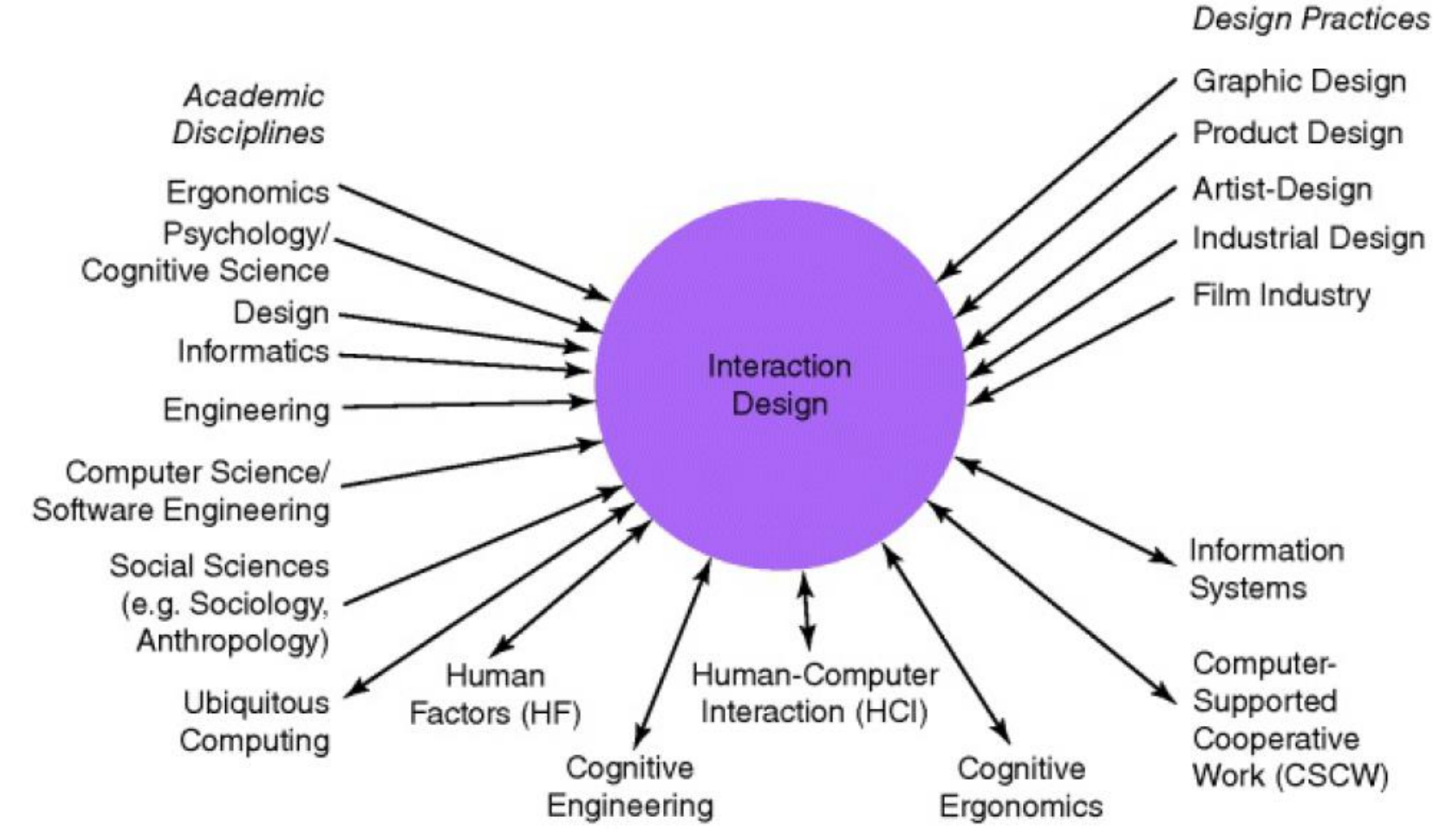
- Human Computer Interaction investigates the interplay between a human user and a computer system or interactive device through the medium of a user interface.
- The joint performance of tasks by humans and computers depends on **human capabilities** to use machines on the one hand, and the design (and design trade-offs) and implementation of **interfaces** on the other hand.
- As a field of study, it is an amalgam of several scientific disciplines since the early 'man-computer symbiosis' suggested by Licklider in 1960
- The human side of HCI derived from physiology and applied psychology, and in particular, from ergonomics

DEFINITION

- The design of products has changed much from the 1960
- Products were used to be designed as system to perform an action; the user has to learn how to use it **-> no interaction design involved**
- Today the tendance is to design products with the user in mind; the user shouldn't put to much effort to learn how to use them **–> interaction design involved**
- In the future the products will learn how the users want to use them



DEFINITION


Design Practices
Graphic Design
Product Design
Artist-Design
Industrial Design
Film Industry
Academic Disciplines
Ergonomics
Psychology/ Cognitive Science
Design
Informatics
Engineering
Computer Science/ Software Engineering
Social Sciences (e.g. Sociology, Anthropology)
Ubiquitous Computing
Interaction Design
Human Factors (HF)
Cognitive Engineering
Human-Computer Interaction (HCI)
Cognitive Ergonomics
Information Systems
Computer-Supported Cooperative Work (CSCW)

DEFINITION

- Interaction could be defined as the exchange of information between two or more active participants.
- There are many different terms floating around today, such as *human computer interaction*, *computer human interaction*, or *experience design*. All means more or less the same thing:

designing a system of some sort that a person can interact with in a way that is meaningful to them

- An interaction designer understands what the user wants to do and how the system should respond
- That system can be almost anything: a game, a menu, a series of connected sensors and lights, a complicated physically interactive application, or even a group of other people

MESSAGES

- Interaction happens via messages sent from systems to users, and vice versa. These messages can be text, speech, colours, visual feedback, or mechanical and physical input or feedback
- One thing that interaction designers talk about a great deal is how to construct and receive messages in a way that is simple and unambiguous for users and for the system.

- Drawback: more complex are the messages and more ambiguous they can be

MODELS OF INTERACTION

- Different models of interaction:
  - **Didactic model:** the system is running continuously, and the user can see into the system, but instead of regulating the behaviour, the user is learning from the output data
  - **Semi conversational model:** the user communicates something to a system and the system communicates something back that allows the user to carry on with a secondary task
  - **Full-fledged conversational model**: the user and the system can fully and constantly interact
  - A simple but good example of this is navigating using a mobile device: the device is constantly updating its position and displaying that back to the user and providing directions, while the user is actively traveling and querying the device for information.

MODELS OF INTERACTION

- The interaction experience is strictly connected to final purpose
- A distinction between **interactive art (IntArt)** and **novel instrument design (NID)**
- **Novel instrument design** aims at create new instruments that:
  - Are innovative
  - Expand artistic ability
  - Better fits to the actual artist needs
  - They will be used by different people
  - It is not connected to a specific artistic piece –> it will be used in different and previously not excepted contexts
- **Interactive art**
  - Interactive art is more focused on the message and the user experience rather than the medium
  - The interaction is designed for the unique piece in a specific contexts

INTERFACES

- The interaction between the user and the systems happens thanks to an interface
- This can be a screen, a control panel, an interactive wall, or simply a microphone and a pair of speakers. The interface is whatever shared materials the user and the system use to send and receive messages
- IntArt and NID has different design principles

- NID
  - Users prefer **attractive interfaces**, they need **functional interfaces**
  - There can be a learning curve but the interaction should be simple and intuitive. The learning curve should be not on the use of system but on thinking what to use it for
  - Users should go back to it without being annoyed

https://www.youtube.com/watch?time_continue=101&v=pHjTBqh8xi4

INTERFACES

- IntArt
  - The interactive system should be the best to make the user do the experience the artists has designed
  - **critical design**, designed systems that not only function but exist to be thought-provoking as well, making users think in critical ways
  - It is more focused on the user emotive experience rather than the attractivity
  - The learning curve should be almost zero
  - It can be annoying if it is what the artists wants to communicate

https://vimeo.com/50200308

INTERFACES

- Hybrid contexts: an artists create his on interactive system for its on performance
  - The interactive system should be the best to make the artists experience he/she desire and to make him/her communicate what the audience wants
  - The design is focused on the artist emotive experience, the functionality and the user experience at the same time
  - There can be an appropriate learning curve

https://marcodonnarumma.com/works/music-for-flesh-ii/

LANGUAGES OF INTERACTION

- There are some models to describe the kind of interfaces to design
  - Physical manipulation
  - Programming code
  - Mouse or keyboard manipulation
  - Presence, location, image
  - Haptic and multitouch interfaces
  - Gestures
  - Voice and speech recognition

SOME SENSORS

LeapBasic

LeapWobbleBass

SOME SENSORS

Empatica

SOME SENSORS

Arduino

SOME SENSORS

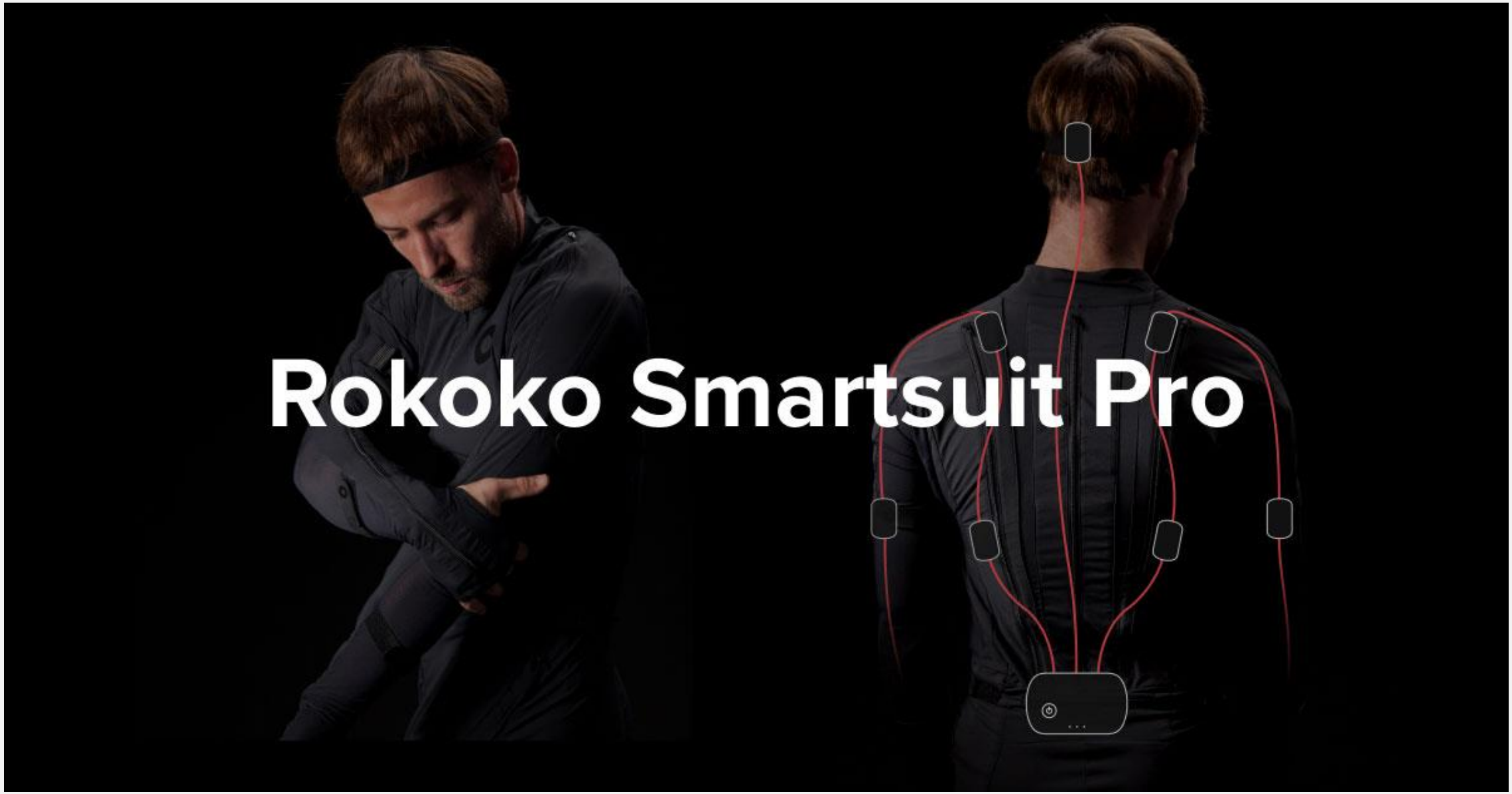
Mi.Mu glove

- Flex sensors measure bend of the finger
- Gyroscope and accelerometers in the wristband
- Vibration motor for haptic feedback
- Buttons and leds

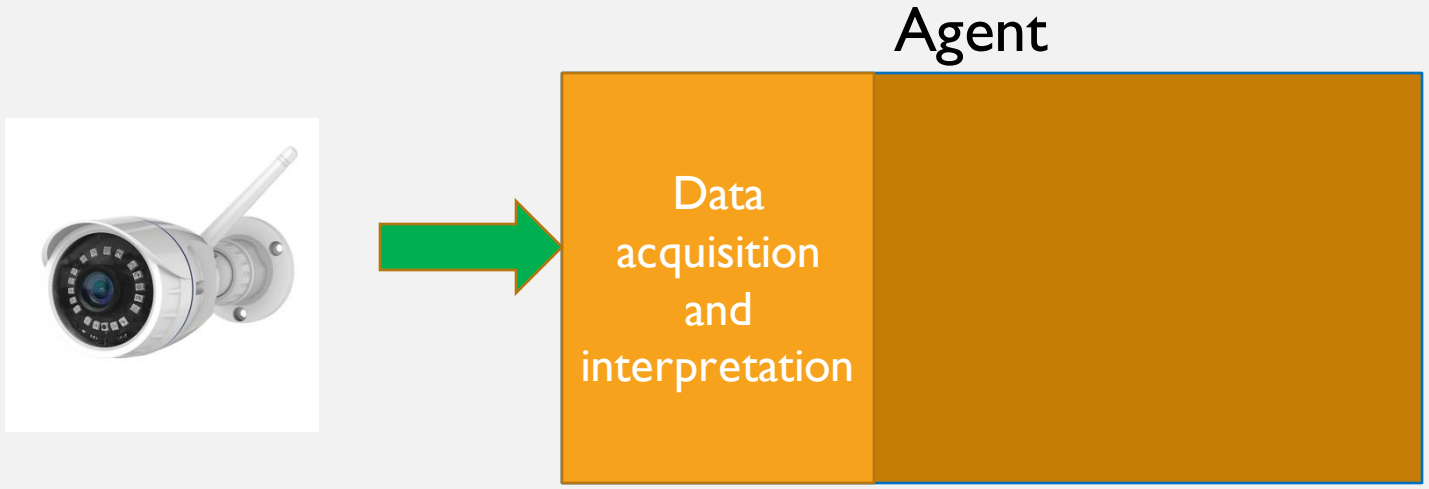
https://www.youtube.com/watch?v=2jR2yi5XPqY

SOME SENSORS

SOME SENSORS



DATA ACQUISITION AND TRANSFORMATION



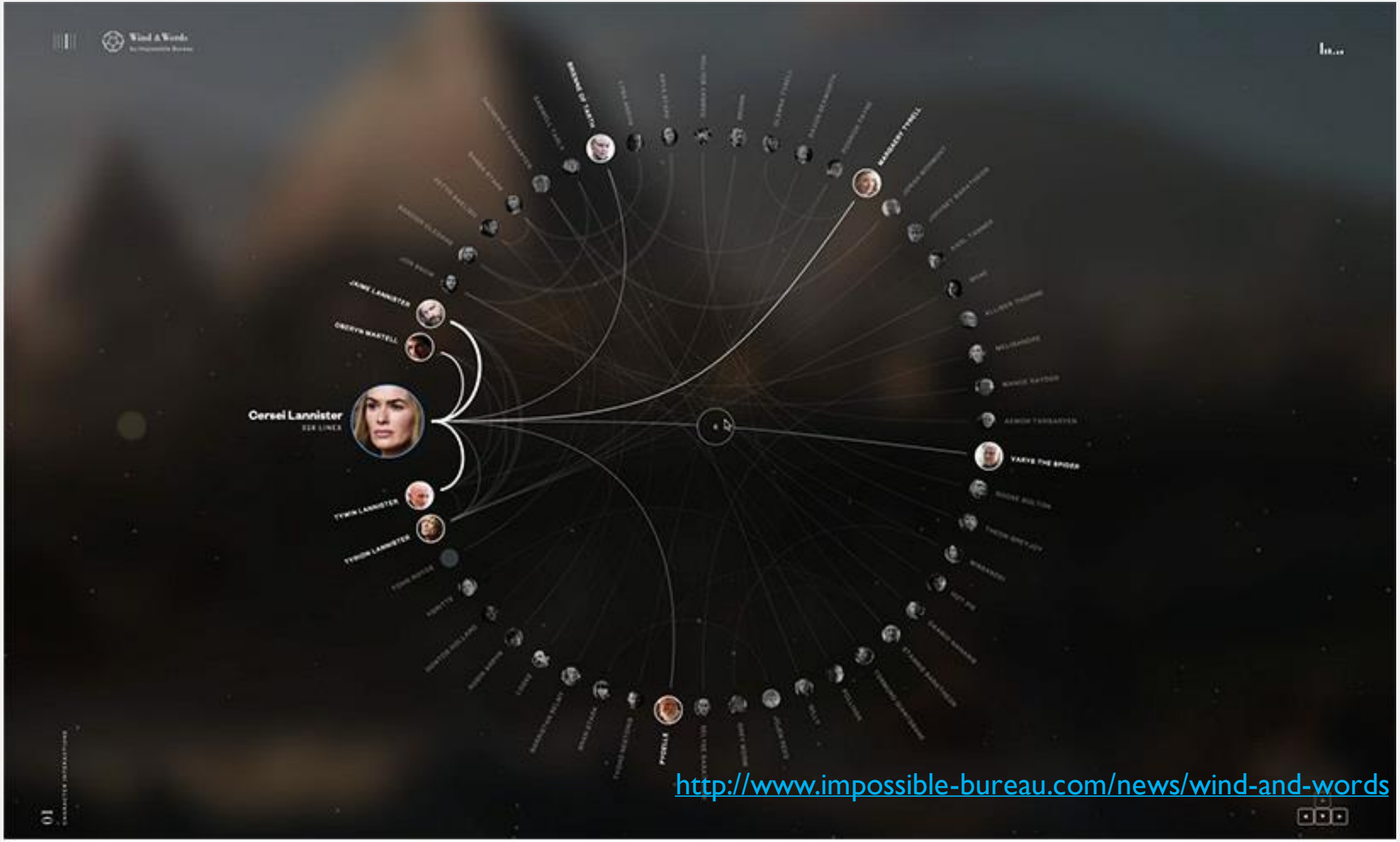
- It is important to consider the requirements for data acquisition and transformation in the interaction design process.

- Real-time VS richness of data
- Explicit semantic data VS binary data to be interpreted
- Error tolerance in data acquisition

INTERACTION AND CREATIVITY

- Here some creative computing areas where interaction design has a great success

- **Data Visualization**
- A well formed data visualization is a powerful tool because it lets a user not only comprehend individual data points but also understand the relationship between what are called data points, detect patterns in the data, and even reconfigure and recontextualize information.
- The interaction of the user can be a process of refining, exploring juxtaposition, mining new data, or storytelling.
- When designing data and the interaction with it, we must consider not only what data is presented, but also how users will interpret that data, what they might want to do with it, and how they would want to interact with it.



http://www.impossible-bureau.com/news/wind-and-words

INTERACTION AND CREATIVITY

- **Experiences Creation**
- There is no purpose but create an experience
- Games
- Interactive installations
- Artistic performances

- **Enabling collaboration between users**
- Users or artists can interact to make the piece
- Networked-based performances

https://www.youtube.com/watch?v=chA-4GRCb-I

INTERACTION AND CREATIVITY

- **Using tools for performance and as performance**
- An application can be used as a way of creating an aspect of performance, aiding a performance, or accentuating a performance.
- Examples:
  - modification of an electric guitar to projects as complex as completely new interfaces for musical development.
  - an interactive application or tool is a means to a performance or interaction, driven by a performer or driven by the audience.
  - some of the most interesting uses of this mode of interaction involve sharing a control between the performer and the audience

INTERACTION AND CREATIVITY

- **Creating environments**
- Reactive architecture, the marriage of architectural practices with computing to create houses and environments that react to users, environmental factors, and external commands

https://vimeo.com/172745960

- **Create a story**
- One of the more interesting themes beginning to emerge in interactive design is the notion of using interaction to tell a story or narrative.
- These sorts of works typically rely on the interface to allow the user to control the flow or direction of the narrative using techniques cribbed from data visualization or gaming.

Re-think the Net by O3LAB

Interactive_wire_leap

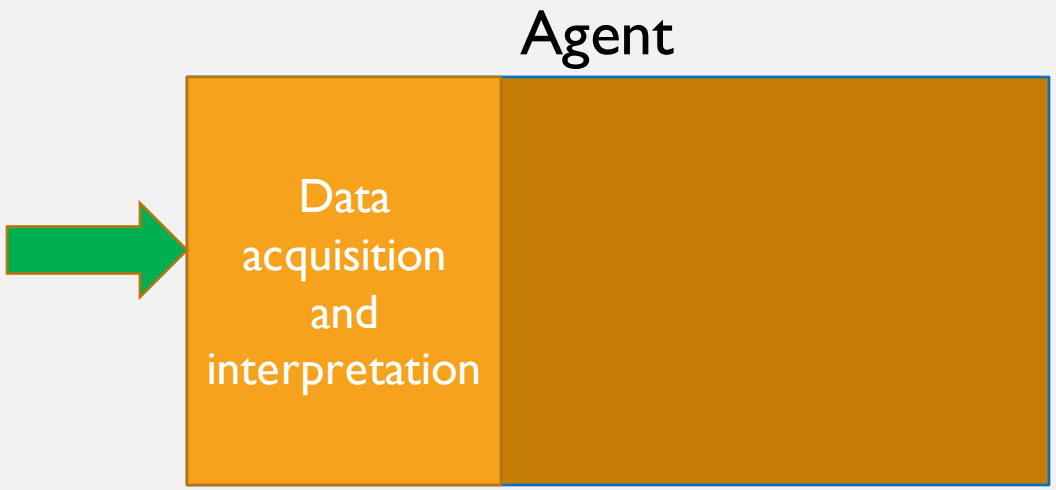
CHALLENGE

Re-think the Net by O3LAB – interaction by using phone

Apple – GyrOSC
Android - Sensors2OSC

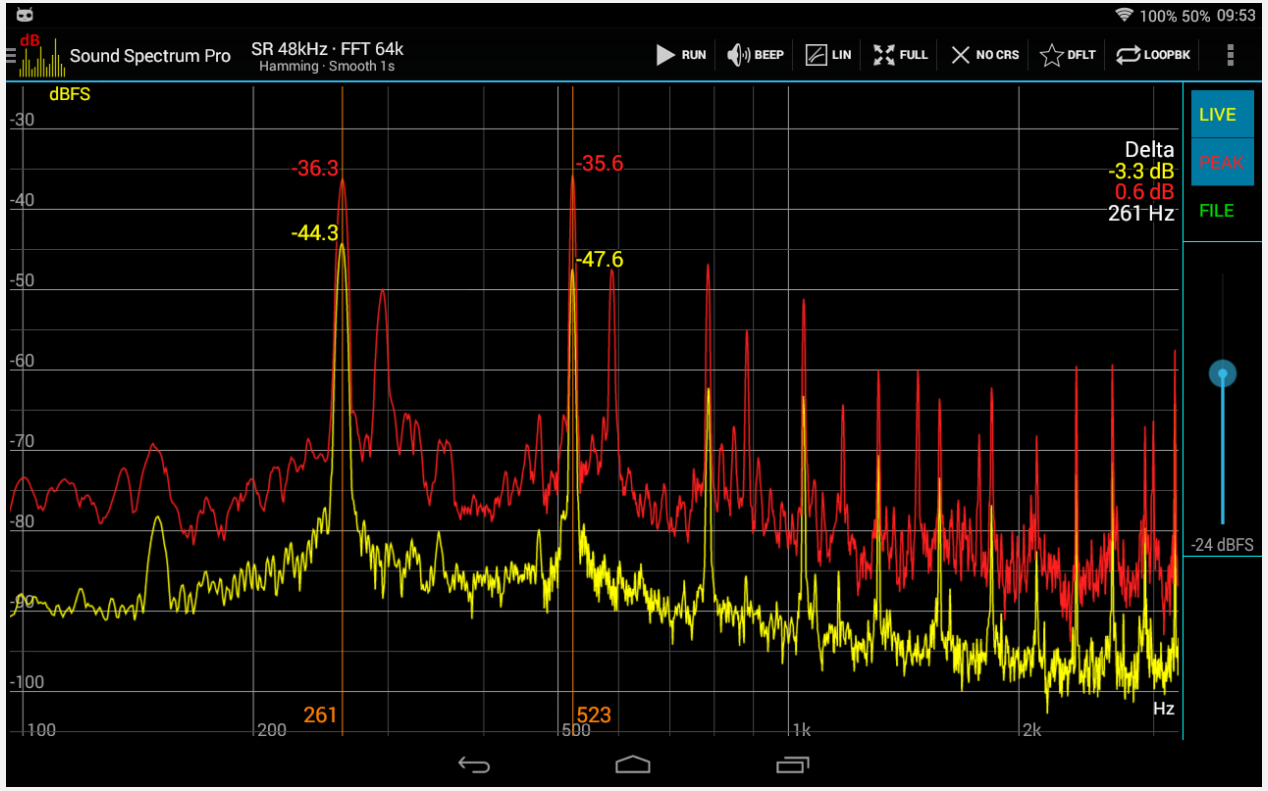
AUDIO DESCRIPTORS - REVIEW

THE SOUND OBJECT



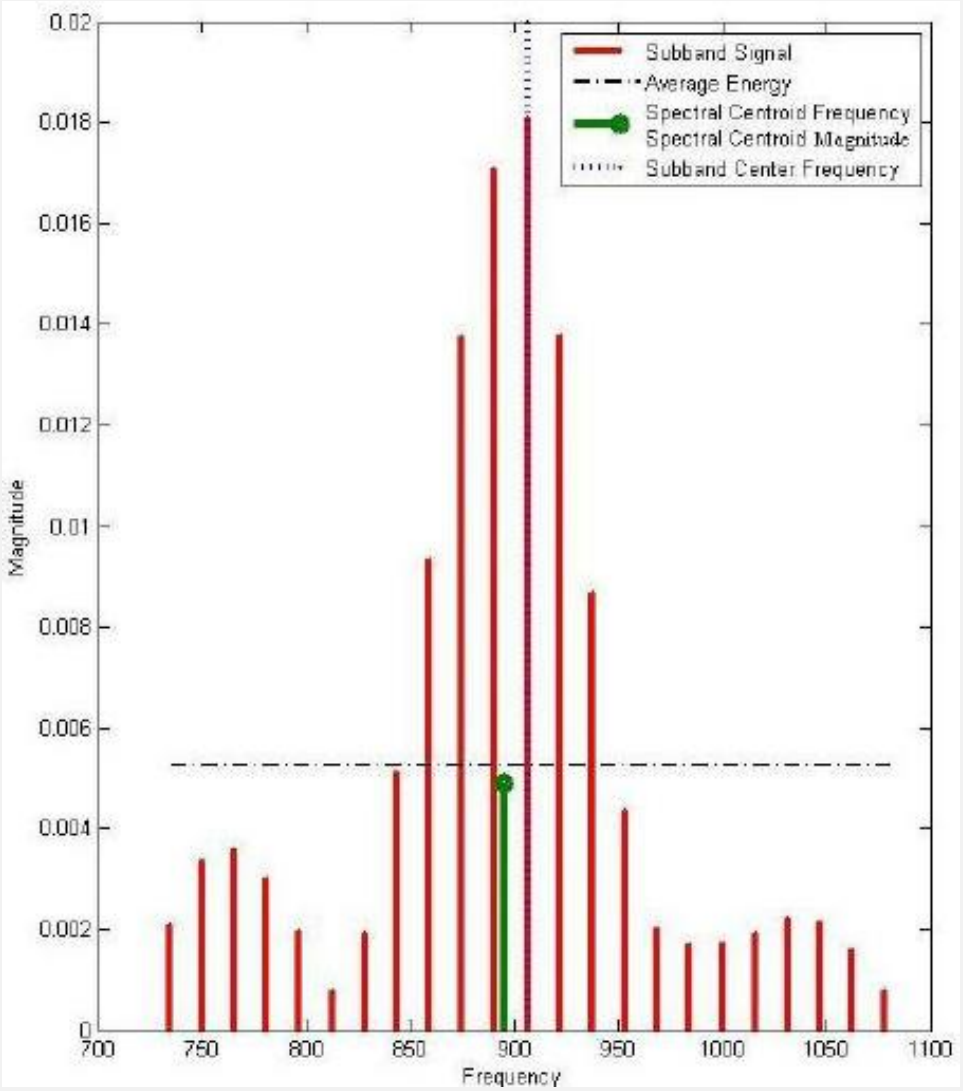
THE SOUND OBJECT

- Sounds are characterized by **intensity**, **timbre**, **evolution in time**
- They can be described through **waveform**, **spectrum**, **envelope**



THE SOUND OBJECT

- The sound is characterized by **intensity**, **timbre**, **evolution in time**
- They can be described through **waveform**, **spectrum**, **envelope**
- In several contexts they are too general characteristics
- Needs of features that are able to capture some specific elements: **audio features**

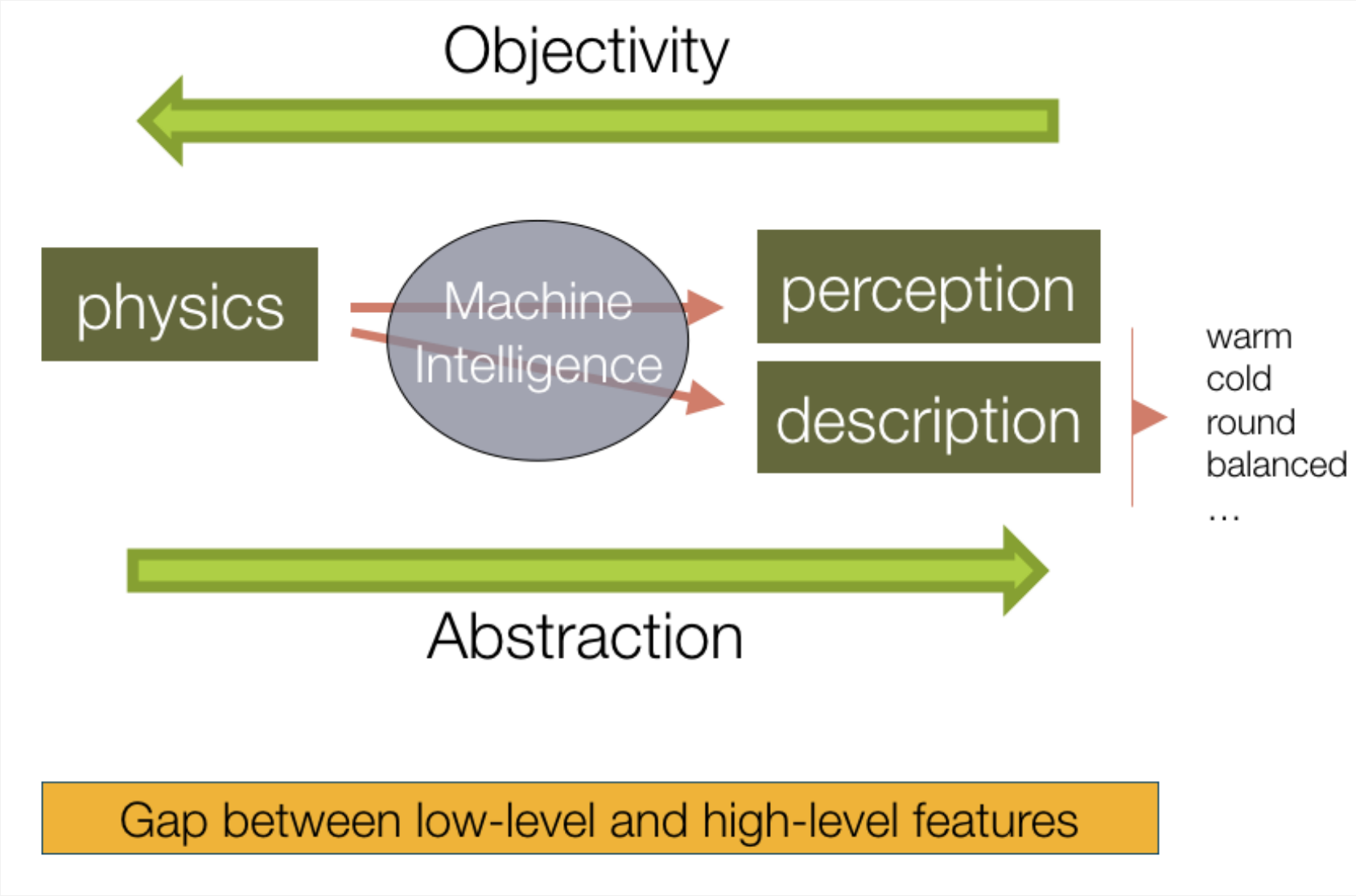


THE SOUND OBJECT

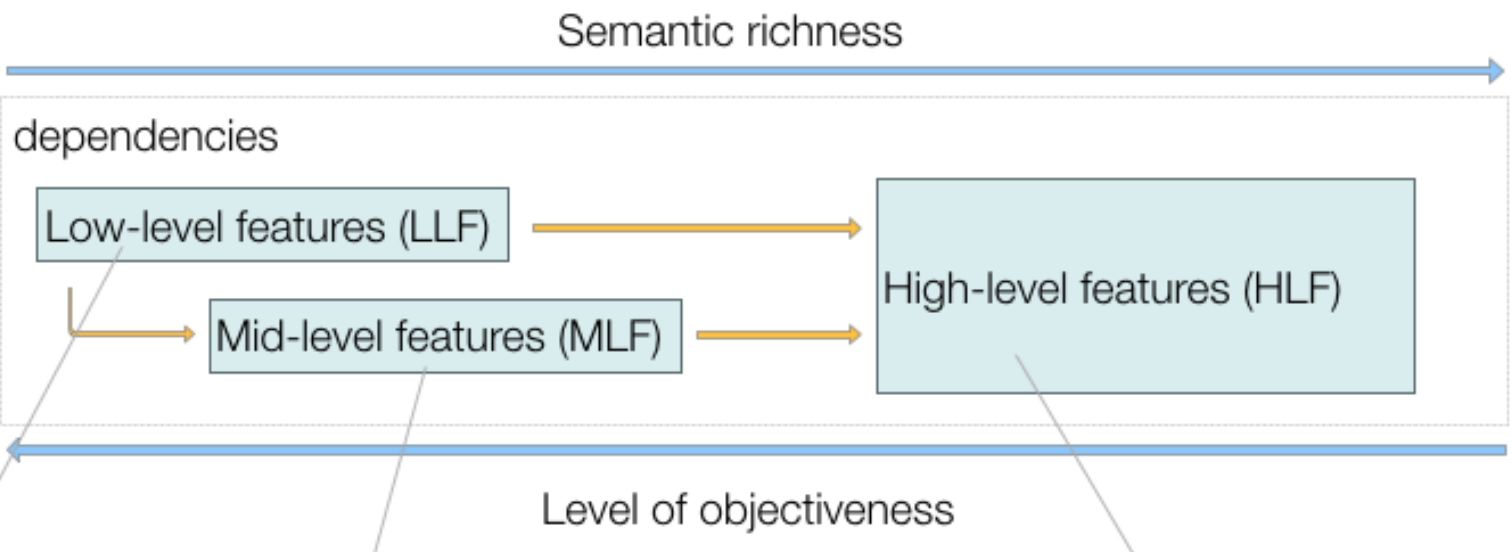
- Features exists each time a digital signal exists (videos, images, bio sensors)

Colour and shape are descriptive features

FEATURES


Objectivity
physics
Machine Intelligence
perception
description
warm
cold
round
balanced
...
Abstraction
Gap between low-level and high-level features

FEATURES



Low-level features (LLF):

- Extracted directly from the signal or the spectrum
- Are not meaningful
- Are objective
- *Spectral Centroid, Spectral Flatness, etc.*

Mid-level features (MLF):

- Group LLF introducing musicological notions
- Introduce some semantics
- They can be objective or subjective
- *Pitch, Chord, Beat, etc.*

High-level features (HLF):

- They are based on LLF and MLF
- They are subjective and meaningful
- Tags are HLF
- *Genre, Mood, etc.*

Feature Visualization

FEATURES

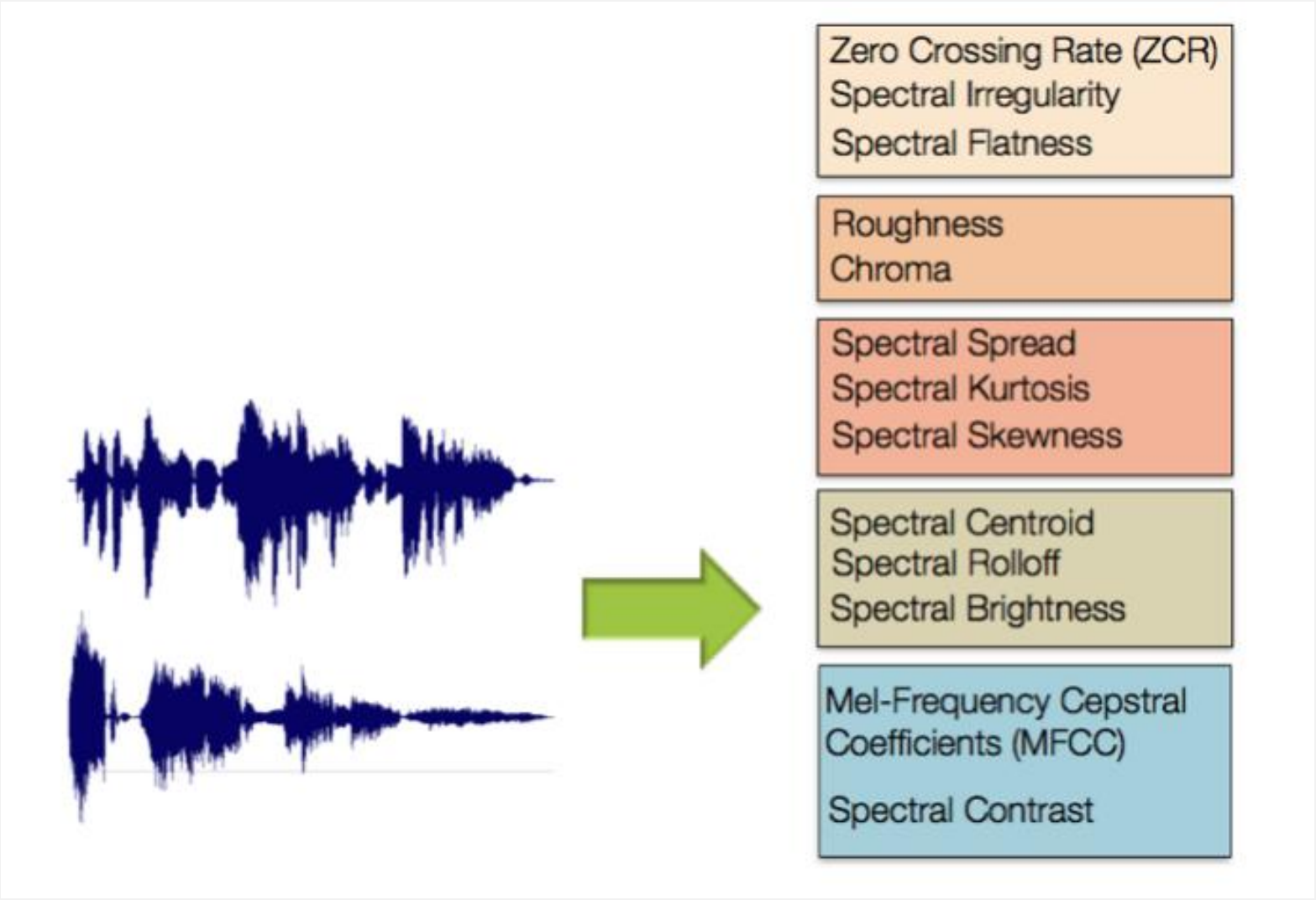
- Features can be:
  - **Global**: valid for the entire signal (music genre)
  - **Local**: valid only for a specific area of the signal (spectral centroid)

  - **Real-value features**: the values are in a continuous space (spectral centroid)
  - **Categorical features**: the values are in a discrete space (music genre)

  - **Content-based**: extracted from the signal
  - **Context-based**: manually labelled

LLF

- Low-level features are compact representations of the spectrum and of the waveform



FEATURE RESOLUTION

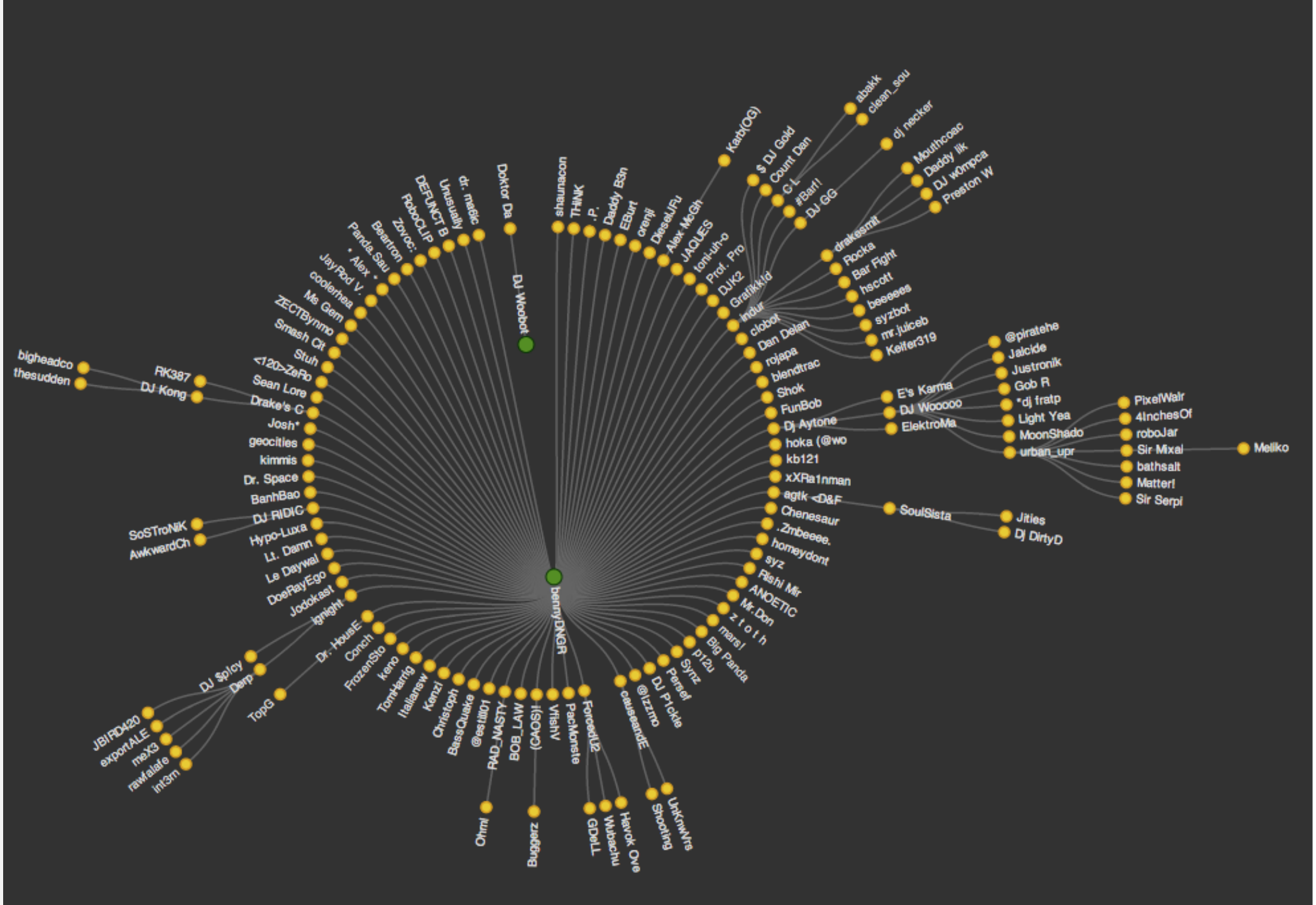
- Features can be computed over the entire signal or for each window of analysis:
  - Short window
    - **Pros**: good for real-time applications, can capture small changes of signal
    - **Cons**: for some features they risk to be less informative (Mid-level features), not informative for signal affected by noise

  - A good practice is to extract features from short windows and then compute the average value for groups of windows

HLF A SPECIFIC CASE – COLLABORATIVE FILTERING

- "The world" for an agent can also the Internet!
- Example: use interactive creative computing for music data visualization of music browsing
- HLF are very useful for human-like music description
- Difficult to provide large reliable HL music features
- Collaborative filtering is one the most used methods
- Collaborative filtering is based on the user-items relationship and user-user preferences

- Describe a music piece with a descriptor if more users that show similar tastes uses that descriptor or semantically similar ones


bennyDNGR
Doktor Da
DJ Woobot
shaunacorn
THNK
.P.
Daddy B$n
EBurt
orenji
DieselJRu
Alex McGh
JAQUES
toni-uh-o
Prof. Pro
DJK2
GrafikKid
indur
clobot
Dan Delan
rojapa
blendtrac
Shok
FunBob
Dj Aytone
hoka (@wo
kb121
xXRa1nman
agtk <D&F
Chenesaur
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homeydont
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Rishi Mir
ANOETIC
Mr.Don
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Big Panda
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Synz
Persel
DJ Pickle
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causeandE
Unknwnrs
Shooting
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RAD_NASTY
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BassQuake
Christoph
Kenzi
Italiansw
Tomkerrig
Keno
FrozenSto
Conch
Dr. HouseE
TopG
Derp
DJ $picy
JBIRD420
exportALE
maX3
rawfalafe
int3rn
Ohmi
Buggéra
ignight
Jodokast
DoeRayEgo
Le Daywal
Lt. Damn
Hypo-Luxa
DJ RIDIC
BanhBao
Dr. Space
kimmis
geocities
Josh*
Drake's C
Sean Lore
<120>ZeRo
Stuh
Smash Cit
ZECTBynmo
Ms Gem
coolerhea
JayRod V.
* Alex *
Panda.Sau
Beantron
Zovoc:
RoboCLIP
DEFUNCT B
Unusually
dr. magic
SoSTroNiK
AwkwardCh
RK387
DJ Kong
bigheadco
thesudden
Kerbi(OG)
$ DJ Gold
Count Dan
C.L
#Barf!
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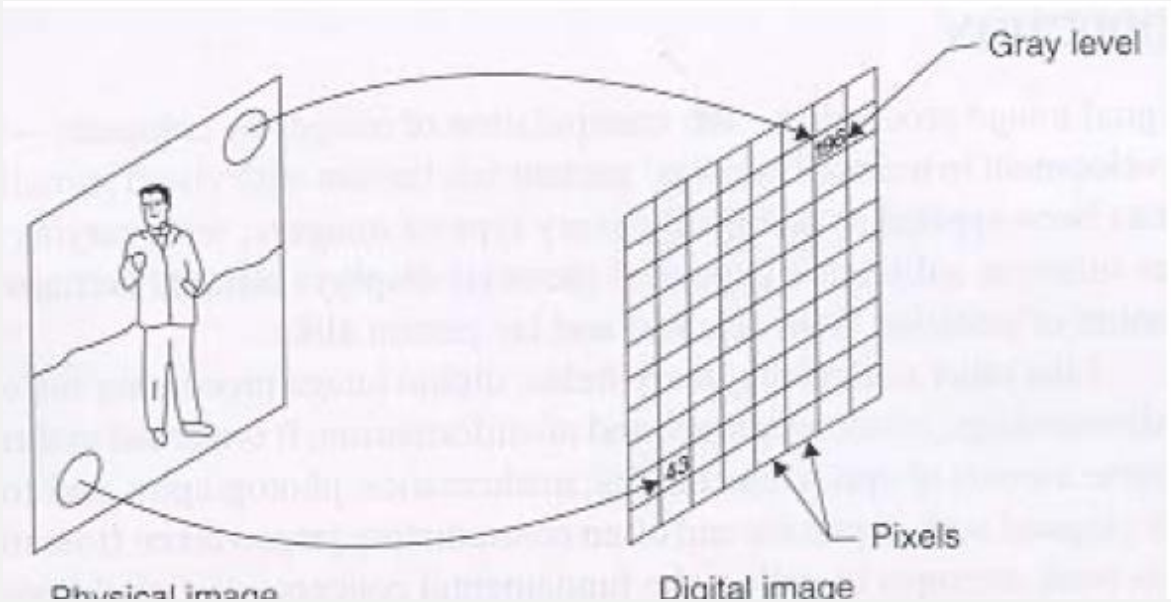
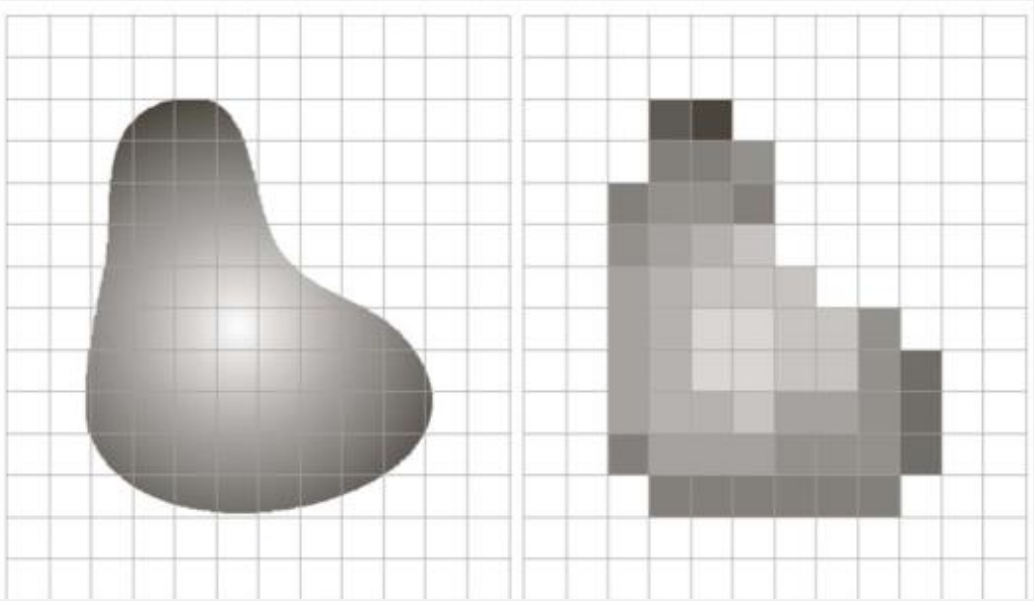
Daddy ilk
DJ wOmpca
Preston W
drakesmit
Rocka
Bar Fight
hscott
beeeees
syzbot
mr.juicelo
Kelfer319
E's Karma
DJ Wooooo
ElektroMa
SoulSista
Jities
Dj DirtyD
@piratehe
Jaicide
Justronik
Gob R
*dj fratp
Light Yea
MoonShado
urban_upr
PixelWalr
4InchesOf
roboJar
Sir Mixal
bathsalt
Matter!
Sir Serpi
Meliko

COMPUTER VISION

DIGITAL IMAGE PROCESSING

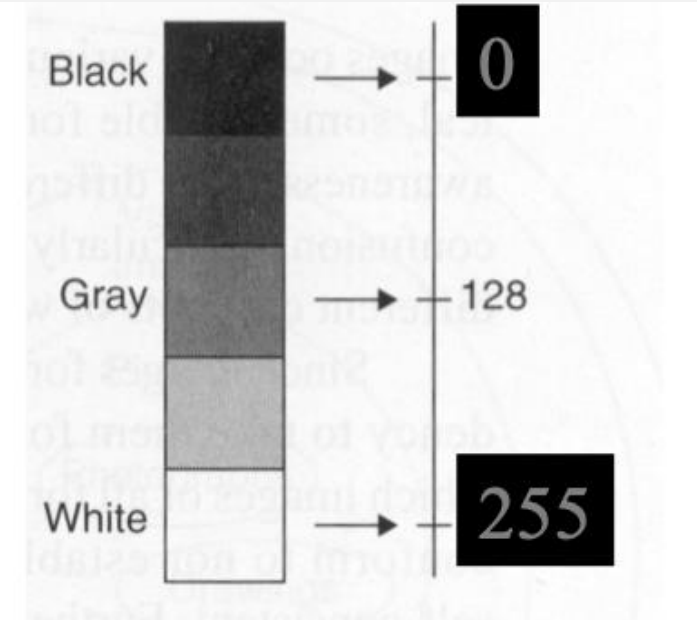
- Series of methods to describe and elaborate digital images



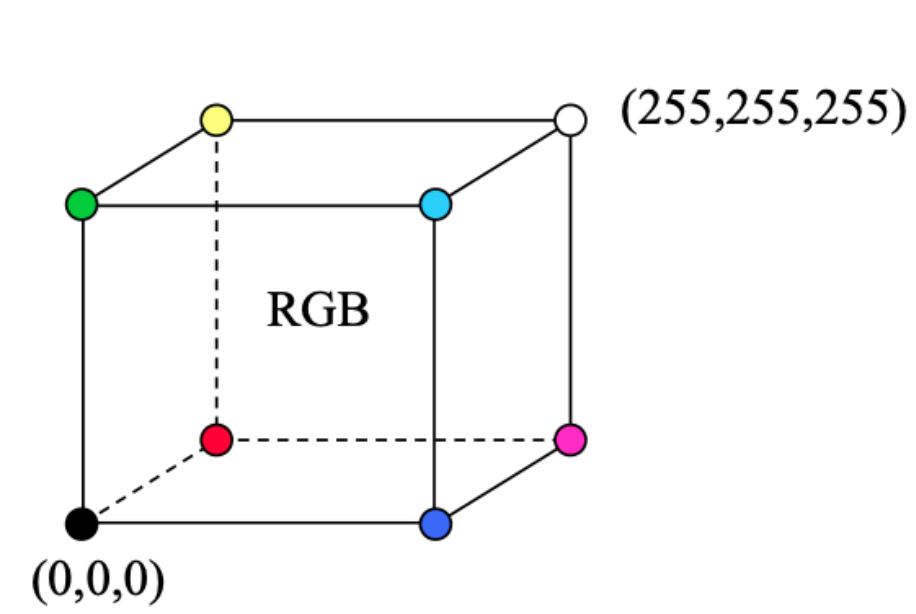


DIGITAL IMAGE PROCESSING

- Each pixel is associated with a value or a set of value that describe the colour intensity in a specific colour space
- Each value is a 8-bit value (0-255)



Gray scale space



RGB space

COMPUTER VISION

- Making useful decisions about real physical objects and scenes based on images (Shapiro & Stockman, 2001)
- Extracting descriptions of the world from pictures or sequences of pictures (Forsyth & Ponce, 2003)
- Analysing images and producing descriptions that can be used to interact with the environment (Horn, 1986)
- Designing representations and algorithms for relating images to models of the world (Ballard & Brown, 1982)

Computer Vision is defined as a field of study that seeks to develop techniques to help computers "see" and understand the content of digital images such as photographs and videos

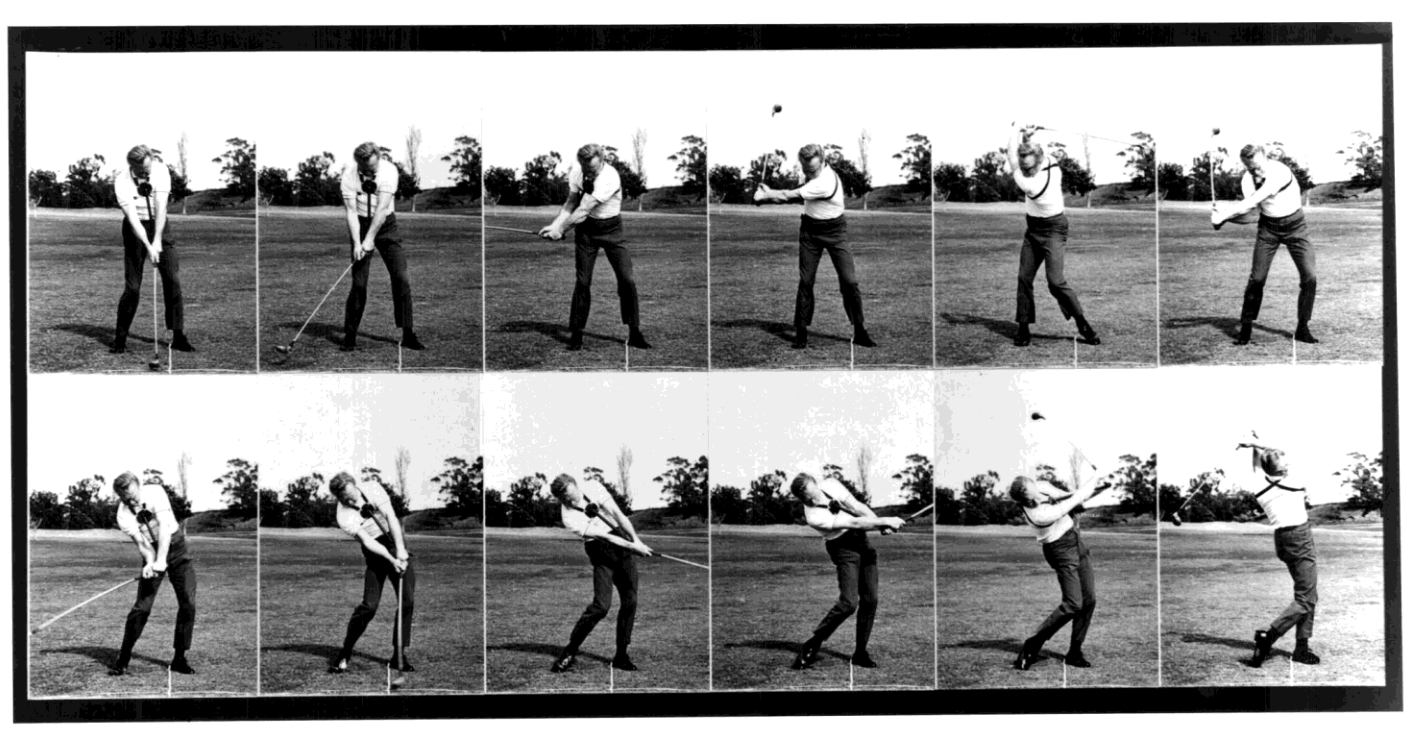
COMPUTER VISION

- Understanding the content of digital images may involve extracting a description from the image, which may be an object, a text description, a three-dimensional model, and so on
- The problem can be solved by using from simple approaches, like graphic-based techniques to more complex methods that use statistical approaches and machine learning
- Some tasks:
  - **Object Classification**: What broad category of object is in this photograph?
  - **Object Identification**: Which type of a given object is in this photograph?
  - **Object Verification**: Is the object in the photograph?
  - **Object Detection**: Where are the objects in the photograph?
  - **Object Landmark Detection:** What are the key points for the object in the photograph?
  - **Object Segmentation**: What pixels belong to the object in the image?
  - **Object Recognition**: What objects are in this photograph and where are they?

https://www.youtube.com/watch?v=GfoqiyB1ndE

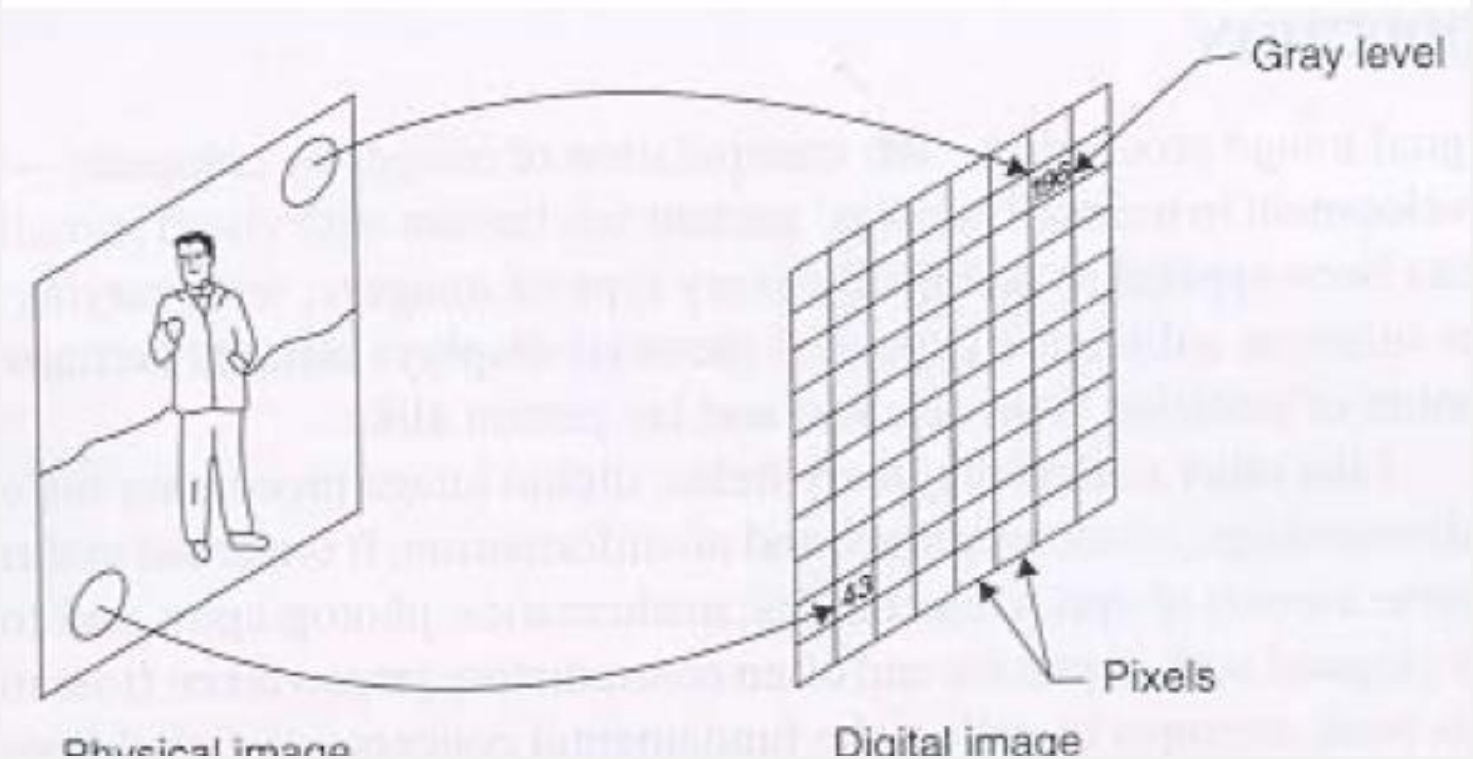
VIDEO REPRESENTATION

- A video is a sequence of images (frames) played at a certain frame rate (FPS)

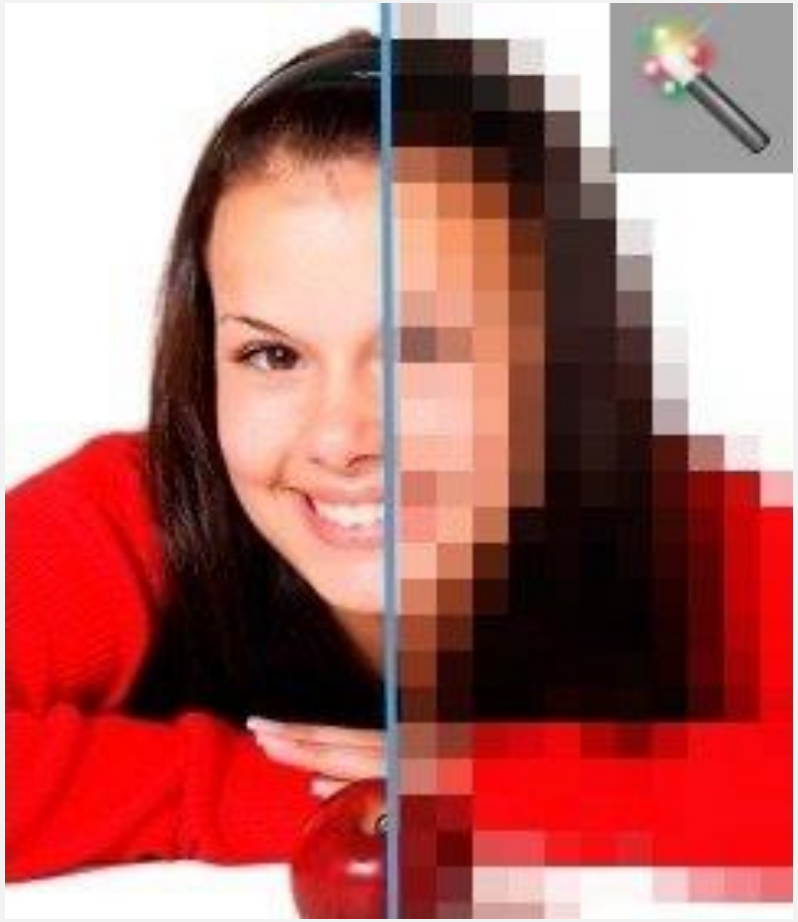


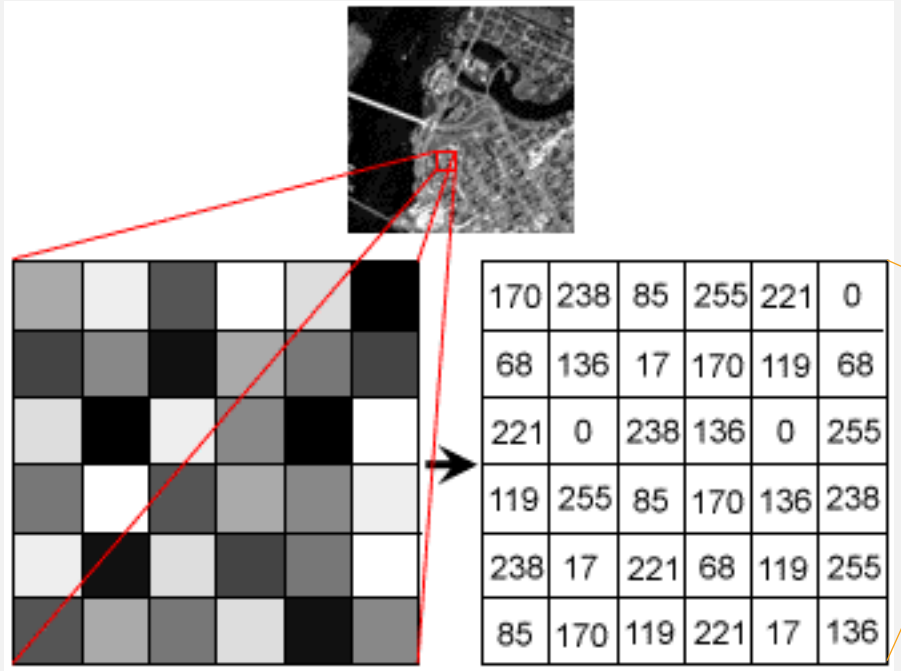
VIDEO REPRESENTATION

- Each frame is a matrix of pixels
- Each pixel has a colour value



PIXELIZATION





170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

$$v = \frac{\sum_{i,j \in P} x_{i,j}}{N_P}$$

$$x_{i,j} = v \ \forall i, j \in P$$

P is a patch

The process will be done in any frames

Video_Processing

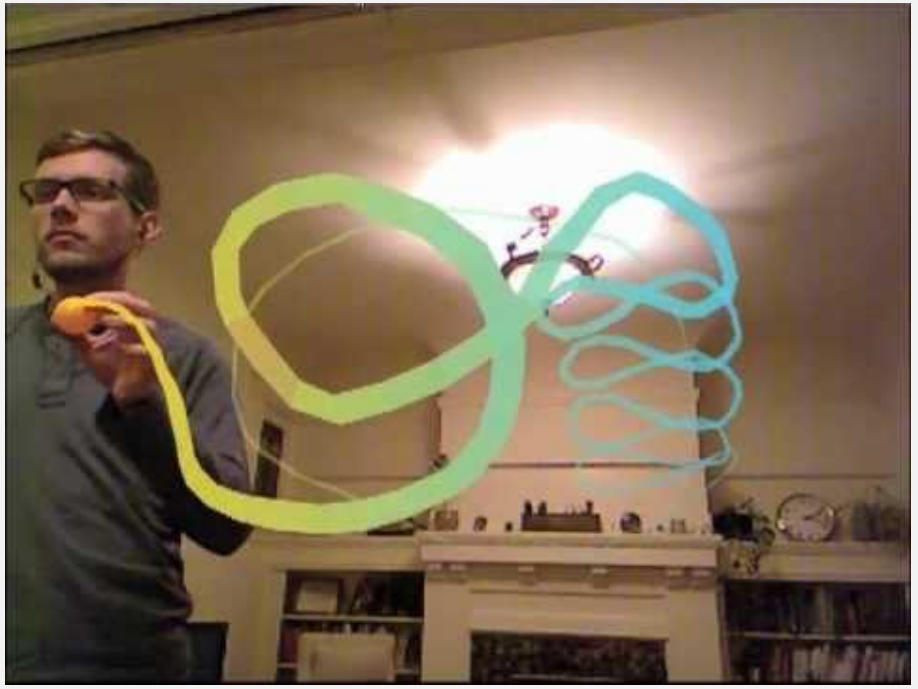
COLOR TRACKING

- Track a specific colour in the video
- Given $\mathbf{c} = [r_c, g_c, b_c]$ colour to track

$$d = dist(\mathbf{c}, \mathbf{x}_{i,j}) \; \forall \mathbf{x}_{i,j} \in \mathbf{I}_f$$

I_f is the f-th frame

- If $d < \tau$ (threshold) then is a pixel to track

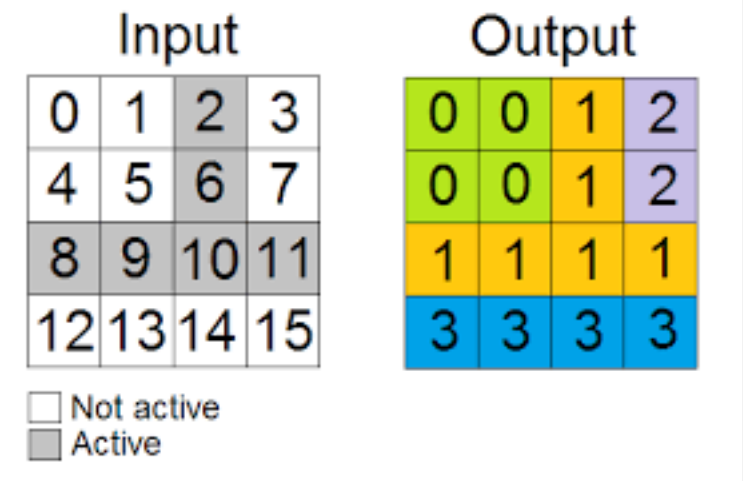


VideoColorTracking

BLOB DETECTION

- Issue: and object is not uniform set of pixels

- Given a pixel -> find connected region for which $d < \tau$



Region Growing

- Maybe several objects are found
- Keep those with the dimension higher than a specified size

The process will be done in any frames

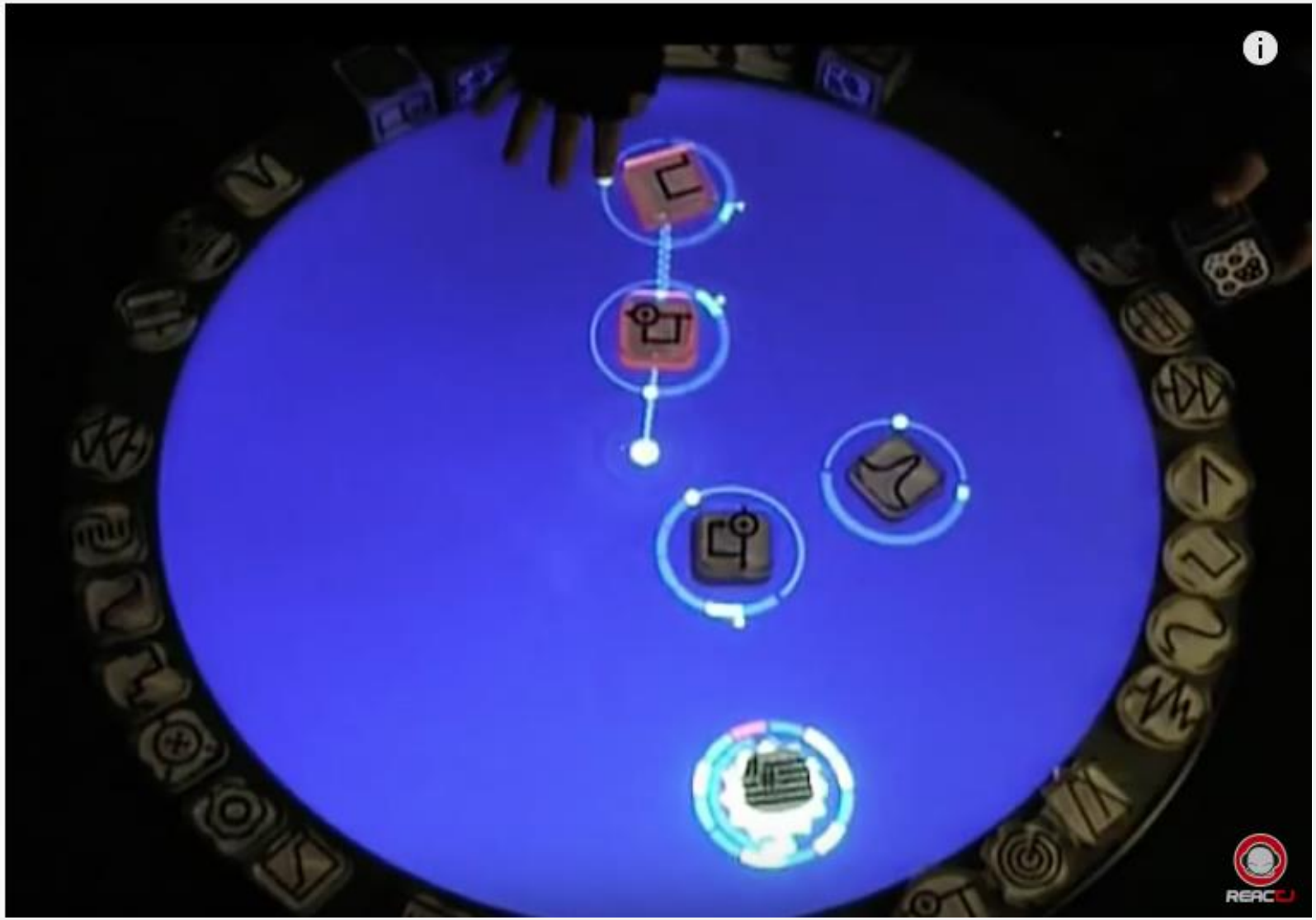
BLOB DETECTION

- It is possible to propagate information to next frames
- Based on the idea that a blob in the next frame will be in a position close to the previous one
- In order to make the technique robust, given a blob in the next frame keep only the most similar and spatially close blob

CHALLENGE

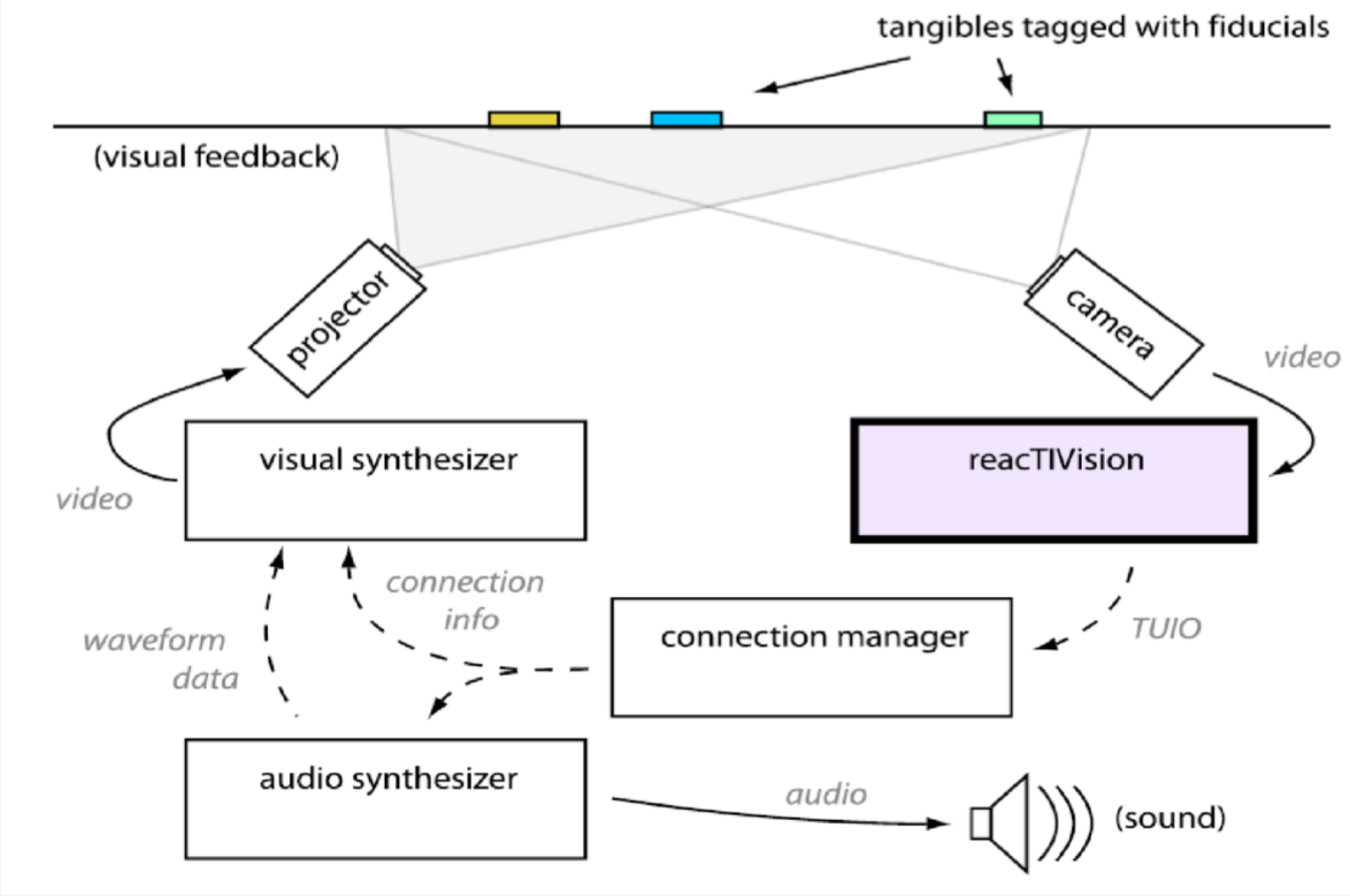
Re-think the Net by O3LAB – interaction with color tracked

REACTABLE



https://www.youtube.com/watch?v=Mgy1S8qymx0

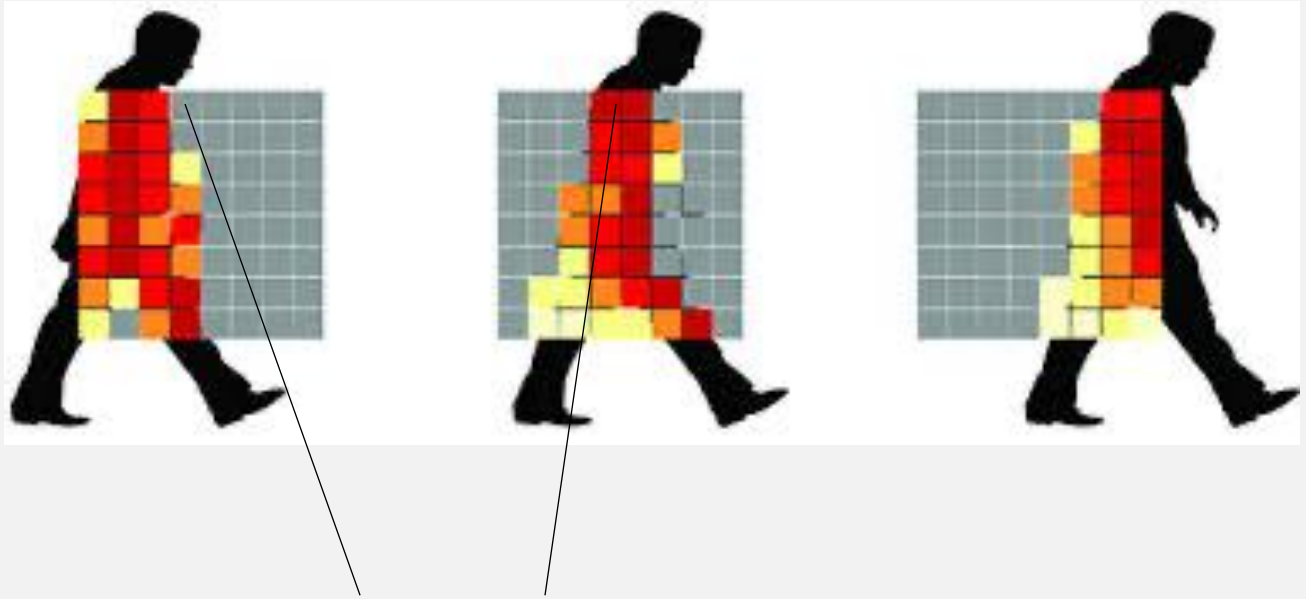
REACTABLE



- Look for blobs
- Compare blobs with fiducials
- Estimate the rotation
- Deliver fiducials ID and rotation value into the system

MOTION DETECTION

- Detect changes in the pixel value for a sequence of frames



$$dist(\mathbf{x}_{i,j,f}, \mathbf{x}_{i,j,f+1}) > \tau \implies \text{motion}$$

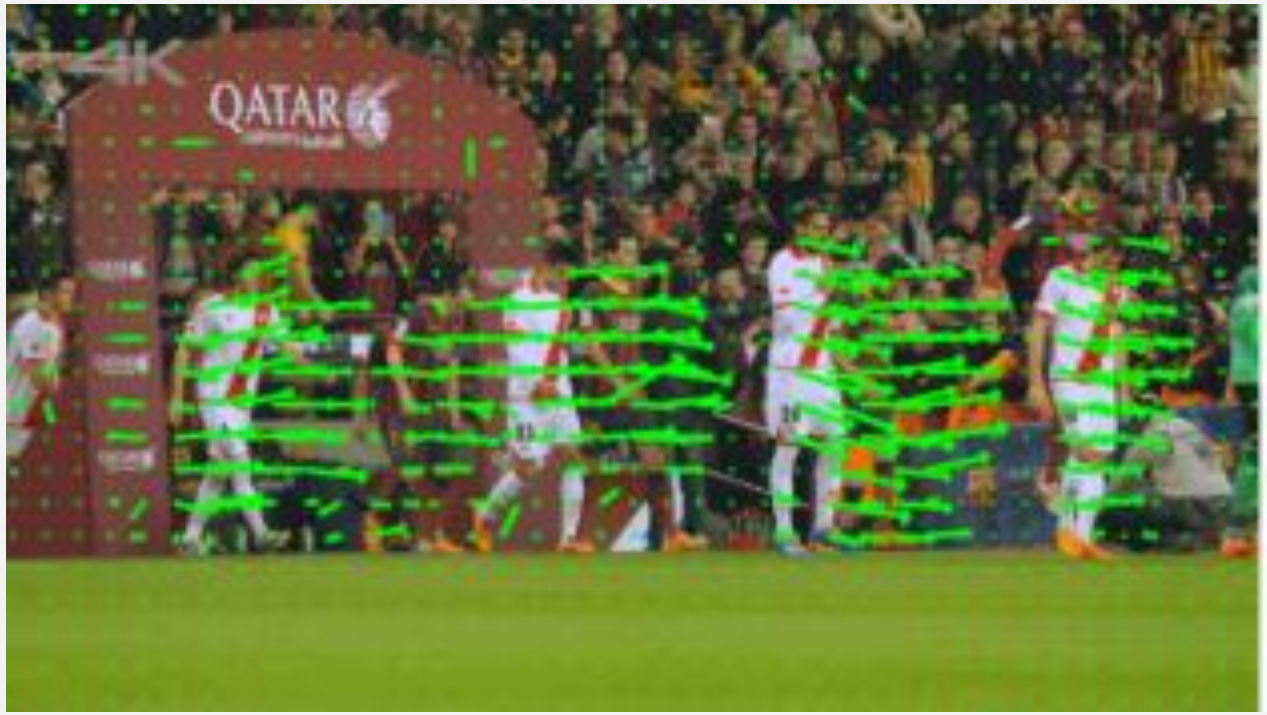
- It can be used to estimate the amount of activity in a video

VideoMotionDetection

OPTICAL FLOW

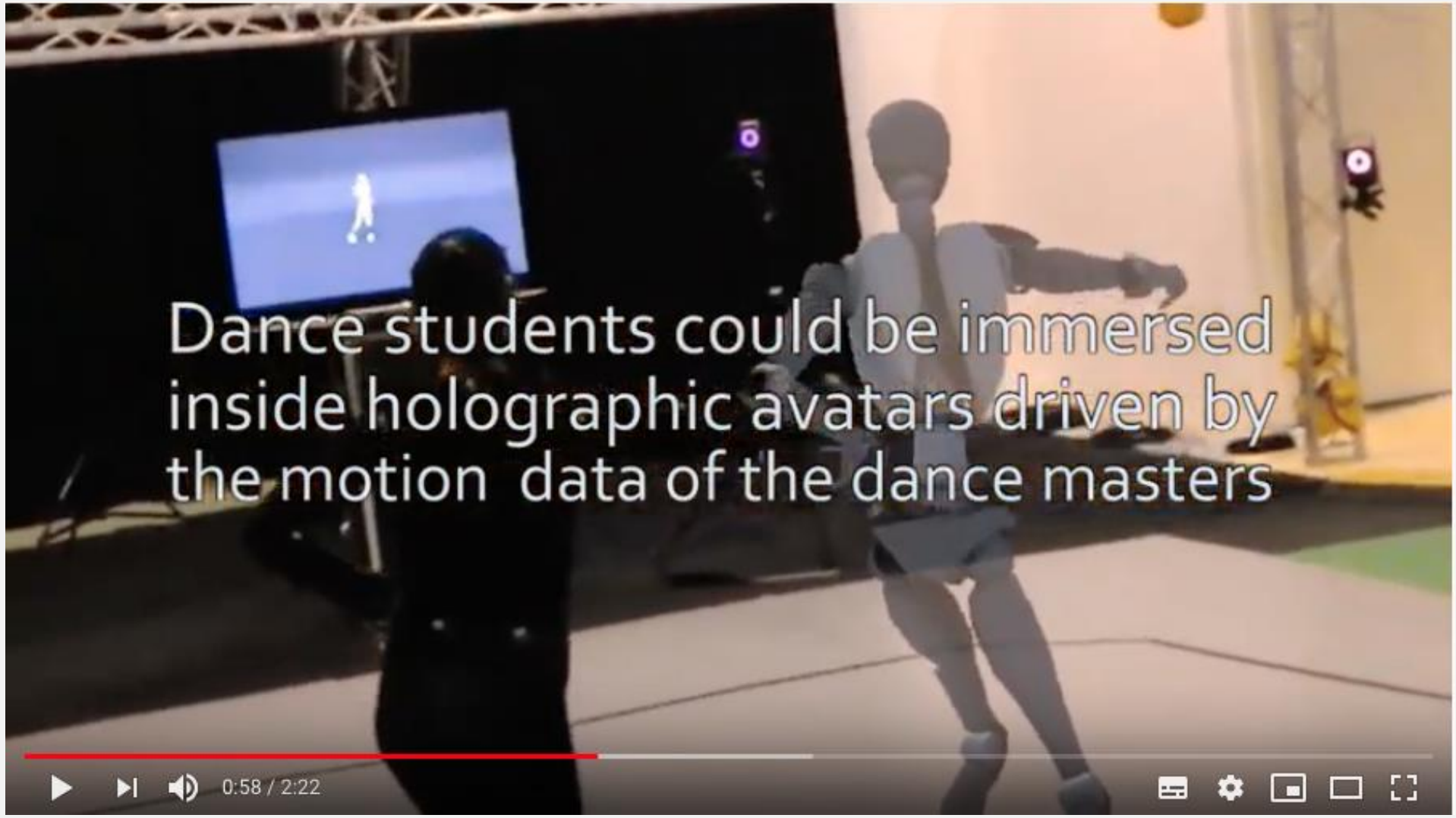
- **Optical flow** is the motion of objects between consecutive frames of sequence, caused by the relative movement between the object and camera
- It allows to estimate the direction of the motion and the speed

OPTICAL FLOW



MOTION CAPTURE

MOTION CAPTURE



https://www.youtube.com/watch?v=C2J_0k3zanY

MOTION CAPTURE

Motion capture

+

Particle System

https://www.youtube.com/watch?v=R6gjipPBUsI&t=27s

MATERIALS

- **References**
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  - Ran Jaykrishna, Computer vision: foundations and applications, Stanford University
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  - G Widmer, S Dixon, P Knees, E Pampalk, T Pohle - Sound to Sense: Sense to Sound: A State-of-the-Art, 2005
  - Alías F., Socoró J.C., Sevillano X. – A Review of Physical and Perceptual Feature Extraction Techniques for Speech, Music and Environmental Sounds - Special Issue "Audio Signal Processing" of the Applied Sciences journal, June 2016
  - David Moffat, David Ronan, Joshua D. Reiss, An evaluation of audio feature extraction toolboxes, Proc. of the 18th Int. Conference on Digital Audio Effects (DAFx-15), Trondheim, Norway, Nov 30 - Dec 3, 2015
- **Further readings**
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  - Katja Kwastek, Aesthetics of Interaction in Digital Art, The MIT Press, 2015
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  - Stefano Papetti · Charalampos Saitis, Musical Haptics, SpringerOpen, 2018