Les senseurs et l'Intelligence Artificielle

Forum Industriel de l'IA
Thierry LAMARQUE
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www.thalesgroup.com

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Thales product decision chain

1 Sensing	2 Platforms	3 Secure data transmission	4 Data processing > Information	5 Decision support	6 Action	7 Assessment
Optronics	Satellites	Secure communication networks	Advanced information processing *(imagery, video, semantics)*		Jamming	Information from sensors
Radars	UAVs, airborne	Tactical datalinks	Data fusion and big data		Air traffic management	Data gathering systems
Sonars	Ground-based surveillance and intelligence	Radio communications	Command / combat management systems		Rail traffic management	Data transmission and processing systems
…	…	…	Air and rail traffic supervision		…	

Many Thales solutions are based on ENVIRONMENT PERCEPTION

Thales products using environment perception

Military systems

- Airborne pod / helicopter / tank
  - Camera with automated orientation / operator
  - Important resolution, optical zoom
  - D/R/I on all targets
  - **Nice to have: list, type, position of targets sorted by priority, automated multi-tracking, scene semantics**
- UAV / UGV
  - Operator camera control, possibly automated
  - Important resolution, optical zoom
  - D/R/I on all targets
  - **Nice to have: list, type, position of targets, automated multi-tracking, platform/camera autonomy**
- Armored vehicles
  - Self protection
  - **Nice to have : transparent armor, IED detection**

Damocles multi-function targeting pod

Watchkeeper, Europe's largest UAV system

Hawkei new-generation light protected vehicle

Thales products using environment perception

Satellites

- Very high resolution images
  - Detection and tracking of vehicules
  - **Nice to have: scene semantics**

Radar

- Doppler data, either 360° scanning or directional
  - D/R/I
  - Ground clutter, especially for airborne systems
- Link with IR camera for identification
  - Operator analysis

Sonar

- Very weak signals detection
- Tracking

Earth observation
Civil, military

Ground Master 400 3D air defence radar

Sensors and systems for UK's **Astute** submarines

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Transportation

- Fare collection systems
  - Road tolling
  - Transportation ticketing
  - **Nice to have: ID, class, number, position**

Security

- Green / blue border & Critical Infrastructure Protection
  - Radar & cameras
  - Identification
- Urban security
  - Persons / vehicles detection/recognition/classification
  - Tracking in a camera network
  - Events detection
  - Forensic
  - **Nice to have: metadata extraction**

Fare collection

States *(border surveillance, national security)*

Cities
(Urban security)

Challenges for perception systems

Autonomous sensors

- Autonomy of sensors and sensing platforms
  - -Unknown context
  - -Camera control shall be autonomous
  - -Communication shall be limited

Urban security

- Metadata and context data gathering in unknown and complex context
  - -Persons / vehicles detection and classification shall be robust to occlusions, distance, camera type, day/night, traffic
  - -Tracking of targets shall be network wide and robust to occlusions, distance, camera type, day/night, traffic
  - -Events detection shall be available for most events and characterized for request by operators
  - -Forensic research on metadata shall be easy and quick

- Adaptability
  - -Operators shall be proposed to provide feedback to the system
  - -Learning shall be envisioned on a long term and online, during the product life

AI paradigms, successes and limitations

AI paradigms

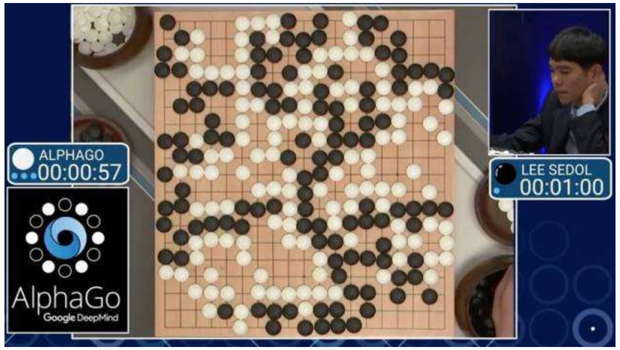
- Learning (NN, SVM, graphs, boosting, Markov models)

AI successes: tasks difficult for humans

- Well defined problems (chess play, indexing)
- Quantifiable outputs (high data retrieval performance)
- Learning & clustering text / figures from large databases
- Actors: IBM, Google, Facebook – MIT, Stanford

Limitations concern environment perception

- General vision & natural language understanding
- Overall world understanding (coffee test capacity)
- Actors: MIT, Stanford, Cambridge University, CNRS, China, …



Computer vision limitations for future systems

A system answers to one function in a given environment

- Scene contrast and lighting
- Cameras angles, field of view, distance to the scene
- Context: scene density and complexity, distance of objects
- Function intrinsic difficulty: interpret behavior vs detect hot spot

Future systems shall

- Require more autonomy for simple decision making (e.g. where to look at for detection - multi-agent paradigm, not only sensor)
- Provide more accurate, in time, semantic information
- Trade calibration and parameters tuning for online, unsupervised, lifelong learning
- Use feedback from operators for self-improvement

Require a mix of Computer vision and AI

Ex : Re-identification de personnes dans un réseau de caméras

Approche multimodale

- Suivi 3D de personnes (tracking)
- Biométrie (visage, iris…)
- Biométrie douce – appariements de silhouette (morphologies, textures et couleurs des vêtements)
- Appariement par le contexte (personnes accompagnées, sac à dos,…)
- Métadonnées autres capteurs non vidéos

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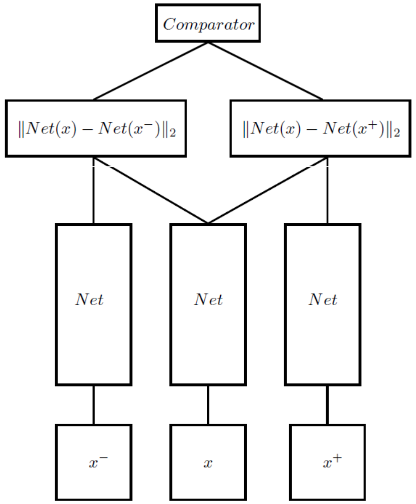
Ex : Re-identification de personnes dans un réseau de caméras

Re-identification de silhouettes

- Catégorisation fine des silhouettes (couleur, texture, sac à dos, casquette, contexte…)
- Deep learning – **Approche Triplet Network**

Zheng et al., ICCV 2015, Microsoft Research

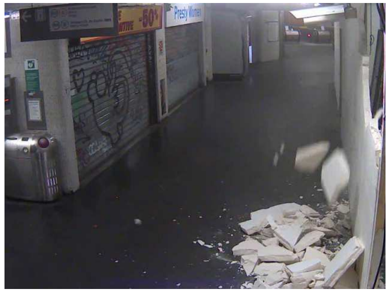


Elad Hoffer, Technion, 2015

Abnormal event detection

Learns "normal" behaviour based on the motion flow in a camera's field of view

- Automatically learns the "normal" motion patterns of people, vehicles and objects in a scene
- Once "normal" is established, the system generates a real-time alert to security personnel on any event considered "abnormal"
- Designed to cope with busy environments, typical of public spaces
- Can compensate for changes in the scene, such as construction work, new installations or detours that change the normal environment.

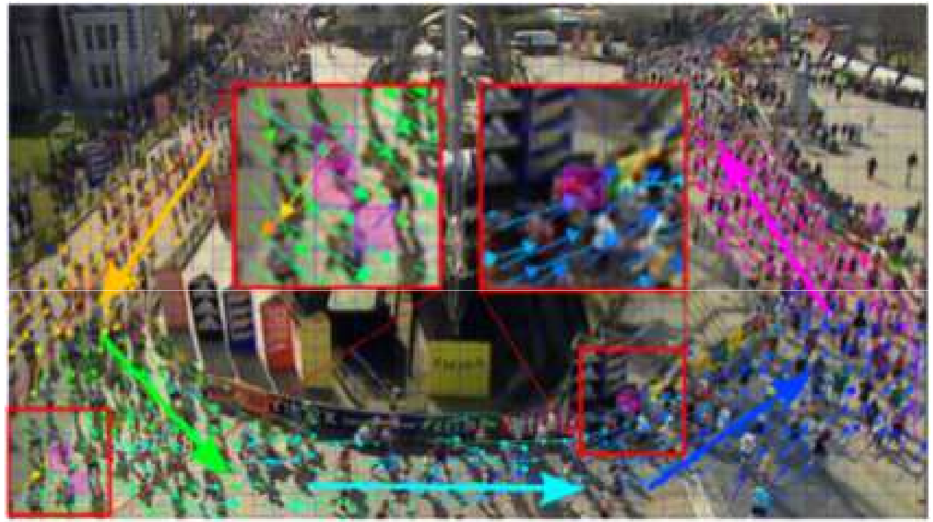


Détection d’évènements violents / comportements

Détection d’agression

Apprentissage faiblement supervisé d’un modèle génératif probabiliste de structures de mouvement

Détection d’événements inhabituels dans la foule



Apprentissage Deep Learning non supervisé de descripteurs de mouvements de foule

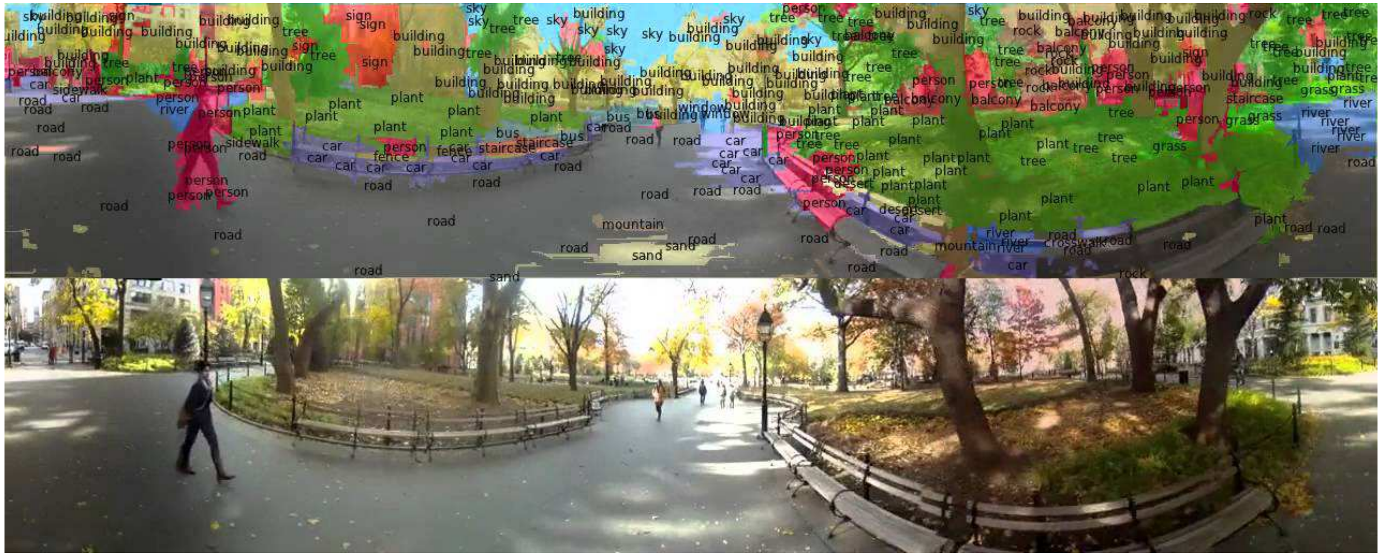
Détection d'évènement violent

Détection d'évènement violent

Reconnaissance automatique et massive d’objets

- Reconnaitre la classe d’un grand nombre d’objets dans leur environnement, pas uniquement sur une photo (cadrée par un humain)

- Rechercher un objet particulier dans un environnement dense avec des occlusions



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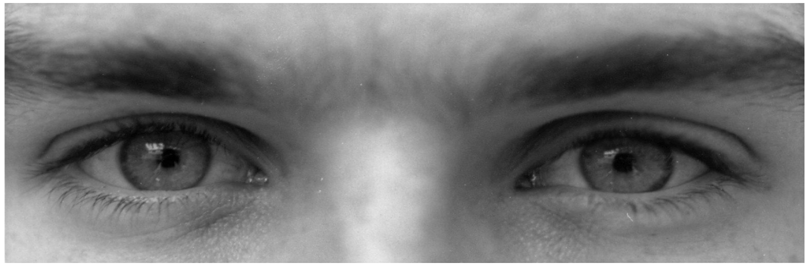
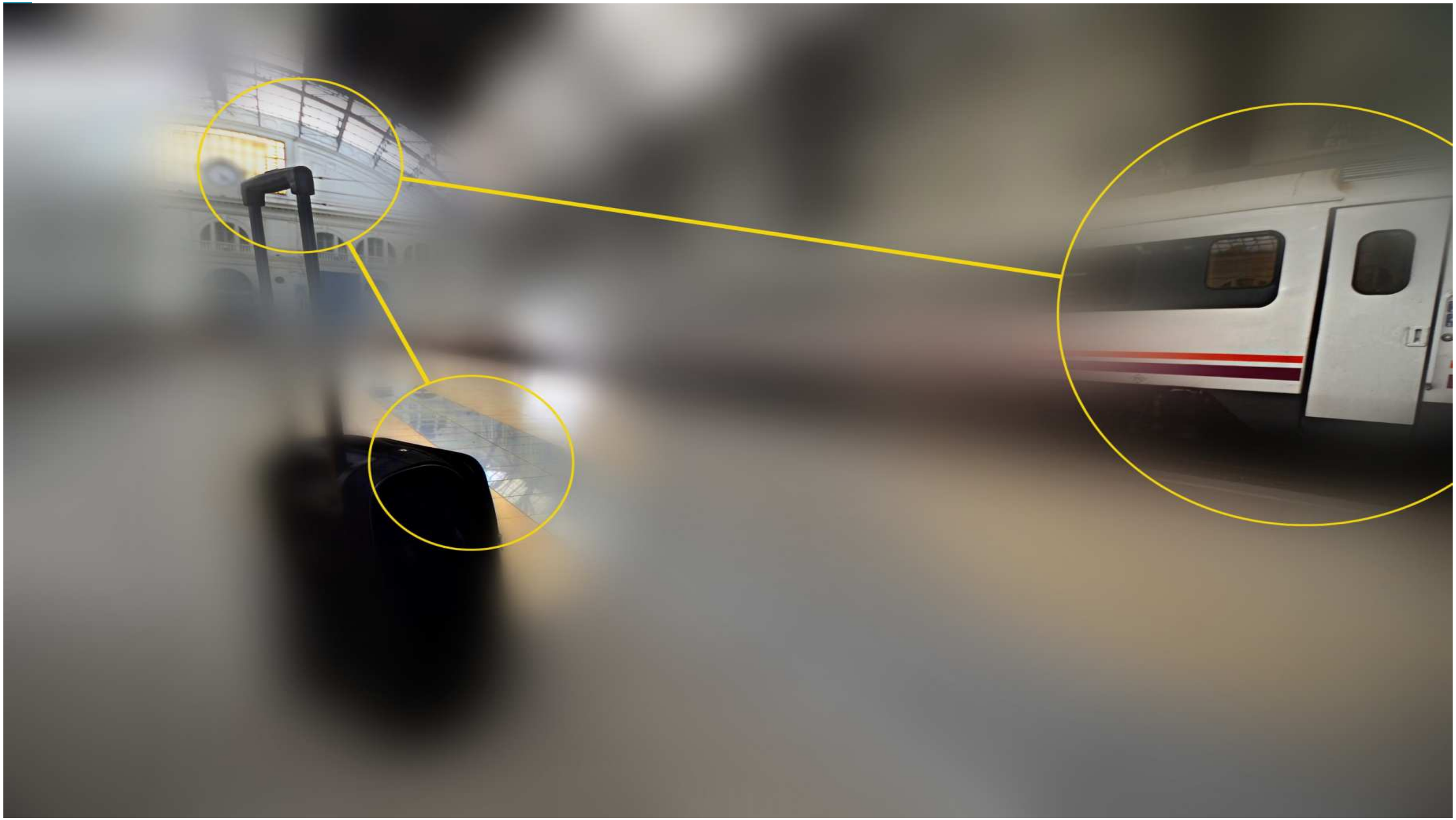
Computer vision vs. the Human vision

Biology

- Eye center is very accurate : 500 rods for 1° field of view / 1mm @ 3m
- Retina is « preprocessing » its inputs: movement, contours, color, corners and movements directions are detected
- Eye do saccadic movements: fixed observations with the eye centers and quick moves
- Vision is task-dependent (e.g. optic illusions)

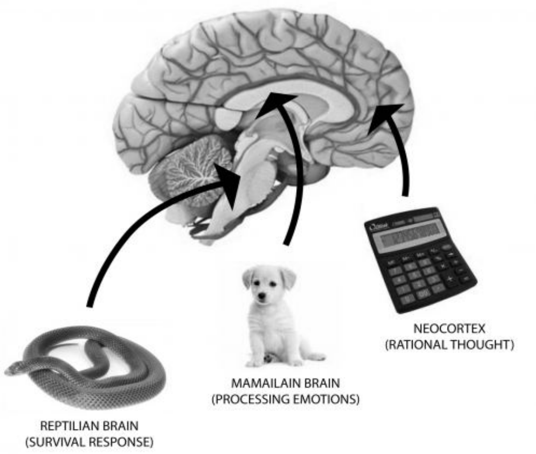


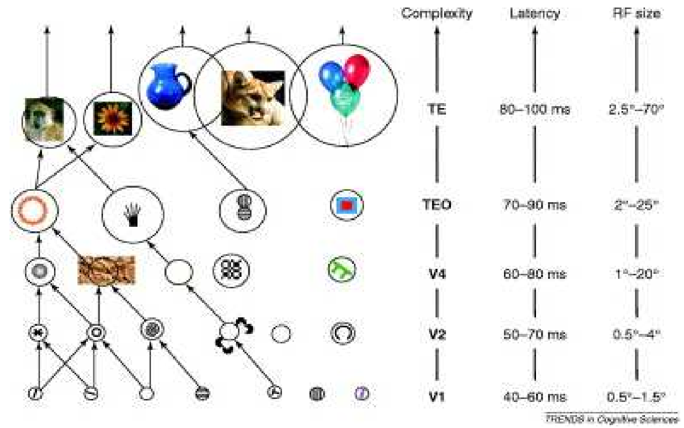


Building new perception systems

A new vision learning system

- No brute scanning but gaze & move autonomy driven by curiosity
- Generic cortex hypothesis for lifelong, unsupervised learning
- Memory and recall as part of the learning framework





How ? Create a thinking system

Learn like a child (Piaget levels)

- 0-2 y: sensorimotor
- 2-6 y: preoperational – represent the world
- 7-12 y: concrete operational – logical reasoning
- Adult: formal operational – abstract & ideological

Creating an « interacting body » in an environment

- Not only a robot: enable interaction and perception - feeling more than processing

Multidisciplinary system approach

The BioVision approach

3 étapes

- Détection de zones d'intérêt par des algorithmes d'attention visuelle
- Exploration séquentielle de ces zones avec un système de vision fovéal: imagerie basse résolution sur un champ large et haute résolution sur un champ étroit
- Apprentissage puis reconnaissance de la classe par des algorithmes de classification spatiale ou spatio-temporelle.

The BioVision platform

Robotic 1 year-child-like platform

- Sensory inputs similar to human visual system
- Movements and gaze control autonomy
- Lifelong learning platform

Today

- Cameras & turret mimicking human eyes with retinal processing
- Curiosity and gaze control
- Hardware control to orient gaze according to the curiosity outputs
- Simple objects recognition based on deep supervised learning

Future platform development

- Small spiking cameras mimicking human eyes
- Humanoid robot for motion, grasping and hearing
- Curiosity and visual saliency controlling navigation and location memory
- Additional sensors: ears, inertial sensors, proprioception, maybe tactile

The BioVision platform objectives

Learning

- Develop, test & assess performances of cortical memory and processing models for structuration, processing and storage of information through lifelong learning (several weeks):
  - Deep Neural Network / Gripon-Berrou Neural Network
  - Hierarchical Temporal Memory (J. Hawkins)
  - Polychronisation (E. Izhikevich)
  - Memristors / True North chip (IBM)

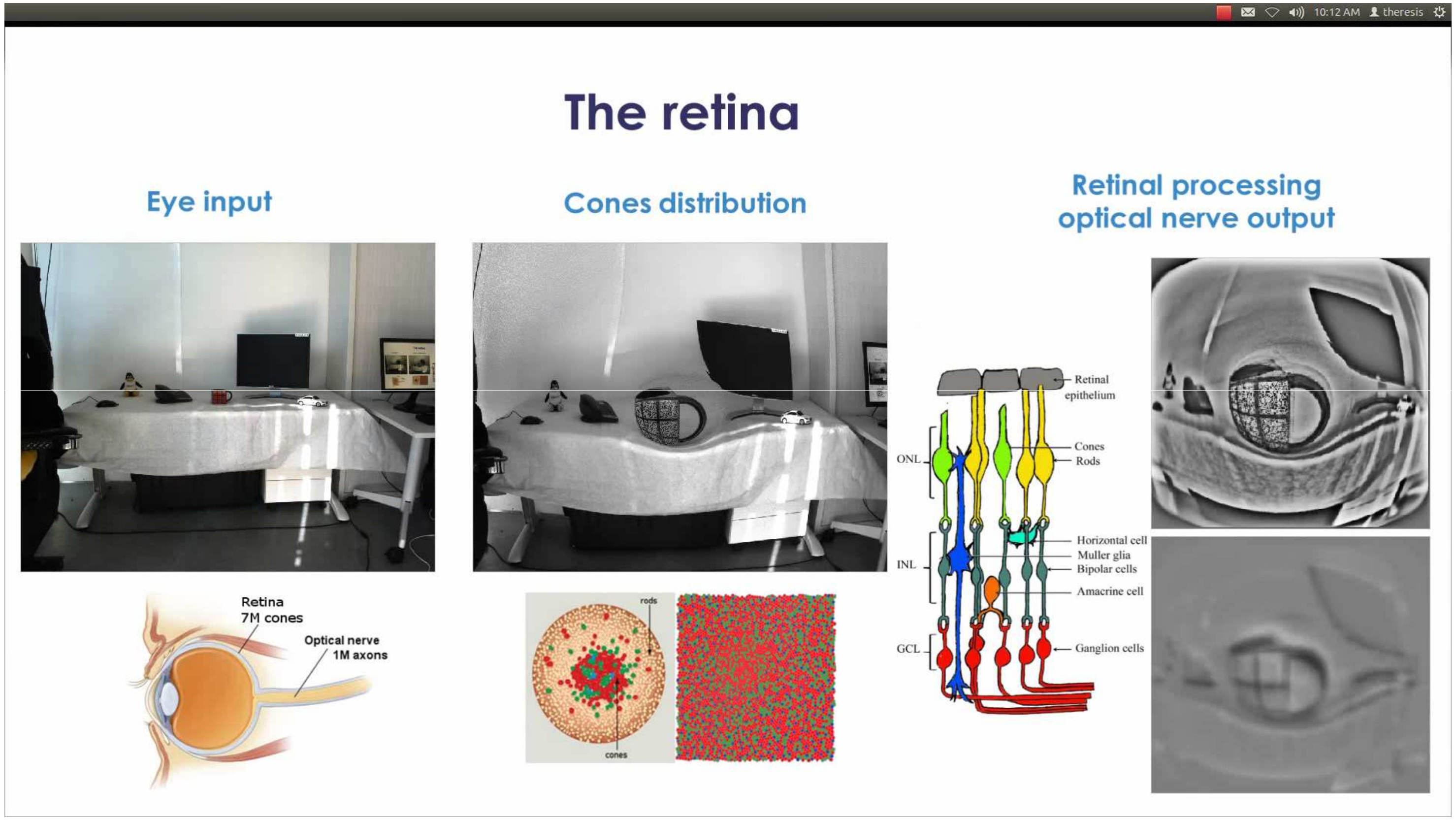
Robotics

- Develop learning algorithms for walking, attention selection and gaze control

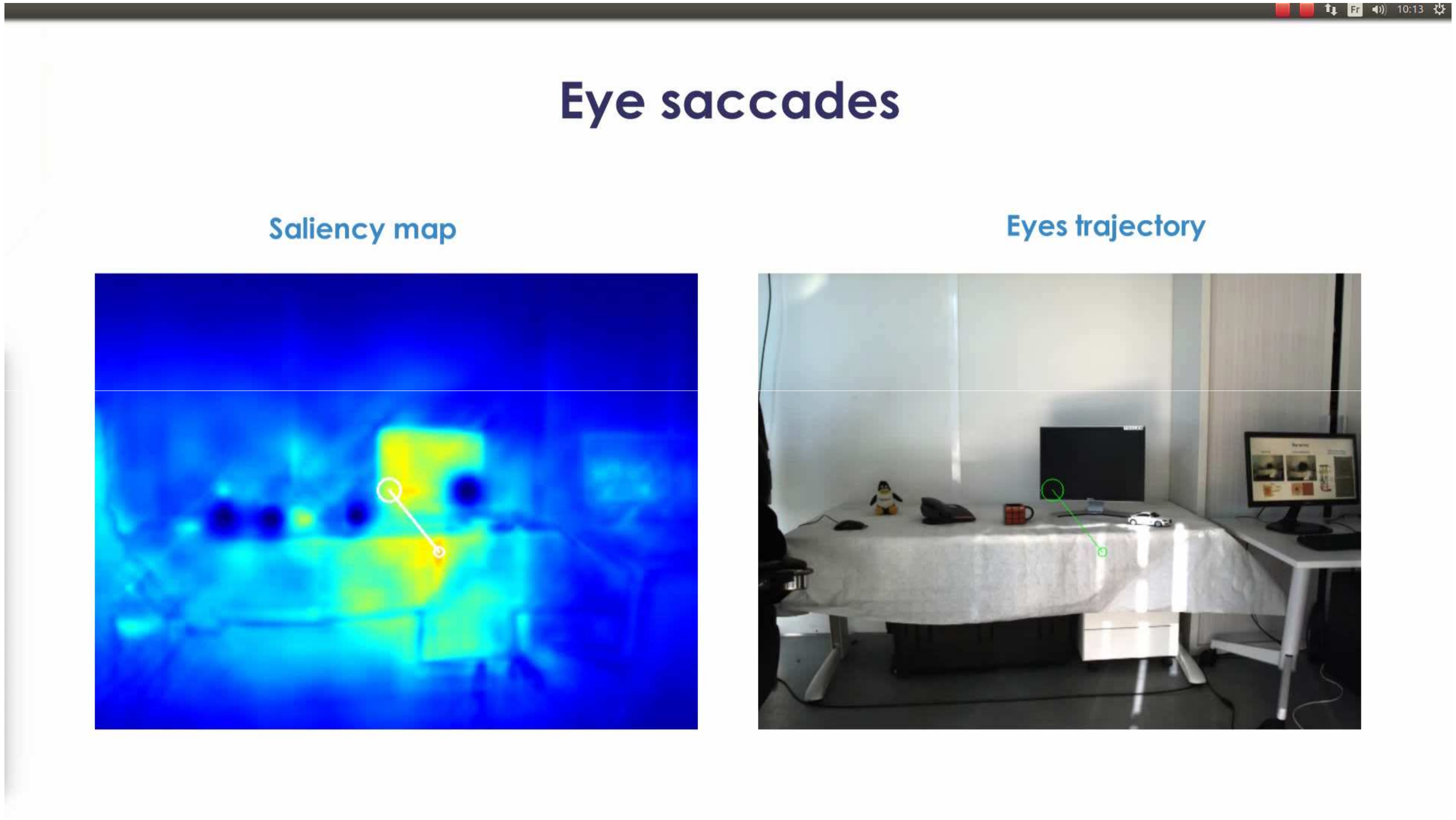
Medical

- Assess medical models of the eyes for vision disorder, provide prototypes for vision implants / prosthesis

Retina model



Saccade model



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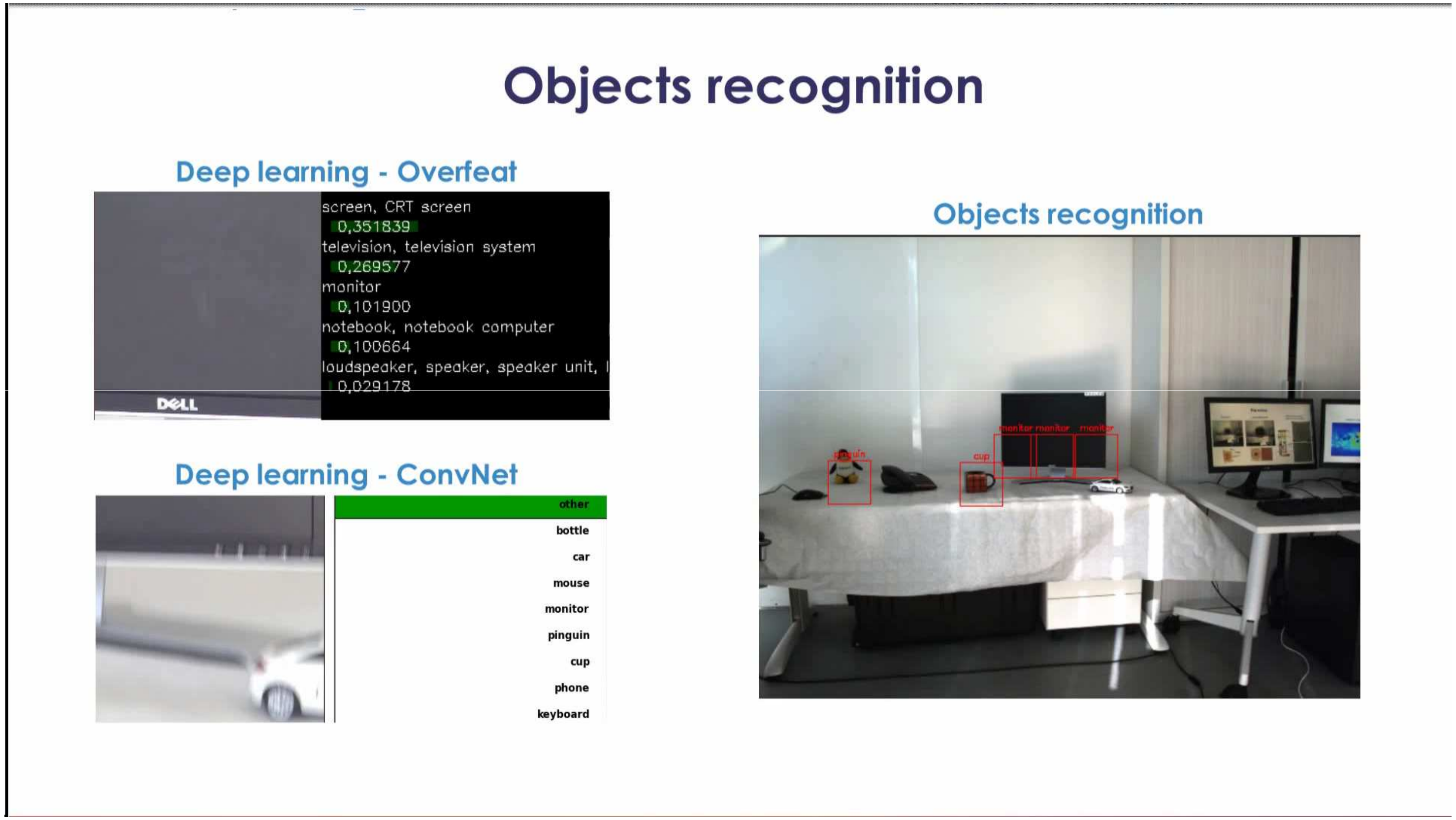
Objects recognition



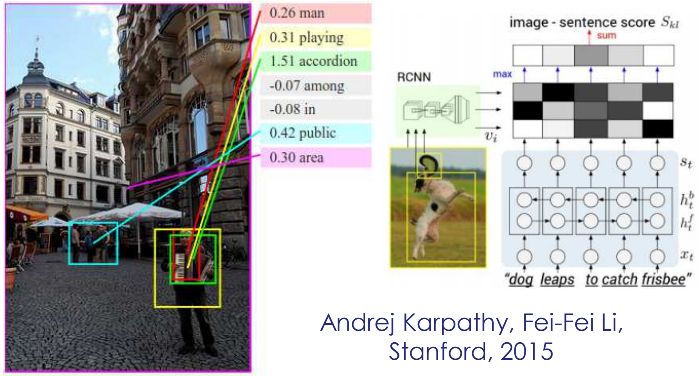
Automatic video captioning

State of the Art

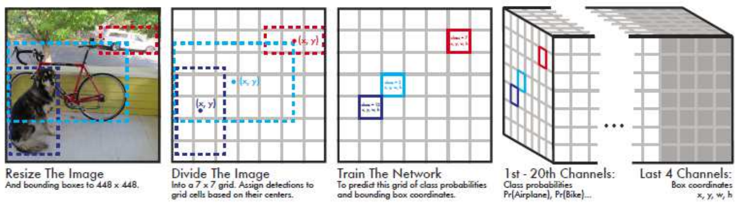
- OK on pictures taken by humans: close range, centered subject (Stanford, Berkeley…)

Work programme

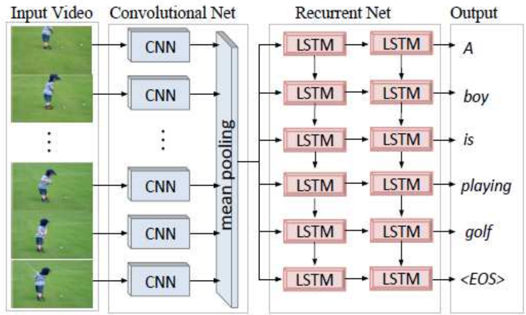
- Extend architecture to CCTV footage, and objects-based video caption



Andrej Karpathy, Fei-Fei Li, Stanford, 2015



Joseph Redmond et al. 2015, Washington, Microsoft



Jeff Donahue, Berkeley, 2015

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Merci pour votre attention

Thierry LAMARQUE

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