Univerza v Ljubljani
Fakulteta za elektrotehniko

Computer Vision
01b – Definitions, history and use

doc. dr. Janez Perš

Laboratory for Machine Intelligence
Faculty of Electrical Engineering
University of Ljubljana

Contents

- What exactly is computer vision
- Where/how did it start?
- Where it is used?

What is computer vision?

- It can be considered a part of the field of *Artificial Intelligence* which aims to achieve
  - Computers that process the data …
  - … in the same way biological organisms do

  (hearing, seeing, talking, thinking)

- So, the computer vision is the ability of computers to “see”
  - Or, to *understand visual information*

Human vs. computer vision

- Understanding of visual information
  - A typical human task

- What kind of scene?
- Where are the cows?
- How many of them
- Where are the trees?

Human vs. computer vision

- Unfortunately, computers are not modelled on human brain
  - They are built in a completely different way
  - They work in a completely different way
- Human vision cannot be directly “ported” to digital computers
  - Human visual system is *universal*
  - As of now, computer vision can solve only narrowly defined problems!
  - Example: autonomous driving is still unsolved

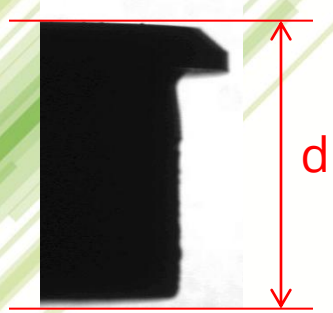
What is computer vision?

- Computer vision aims to generate
  - symbolic description of the scene…
  - based on one or more images or videos …
  - taken by one or more cameras.

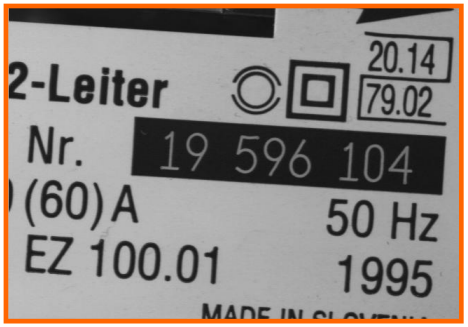
What is computer vision?

- Symbolic description of the scene is…?
  - Goal/task dependent!

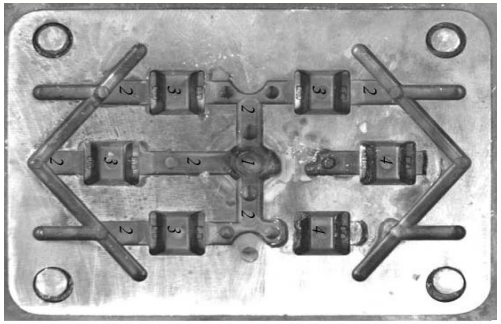
N players = ?



d = ?



Nr. = ?



3D model = ?

From image to scene description

- Let's see a conceptual example
  - Let's assume that the task is 2D measurement
- A typical computer vision algorithm…
  - e.g. as used in manufacturing
- …consists of the following:
  - Image preprocessing
  - Image processing
  - Feature extraction
  - Linking of partial results into the coherent scene description

Image preprocessing

- Purpose: to improve image quality
- e.g. noise removal/filtering

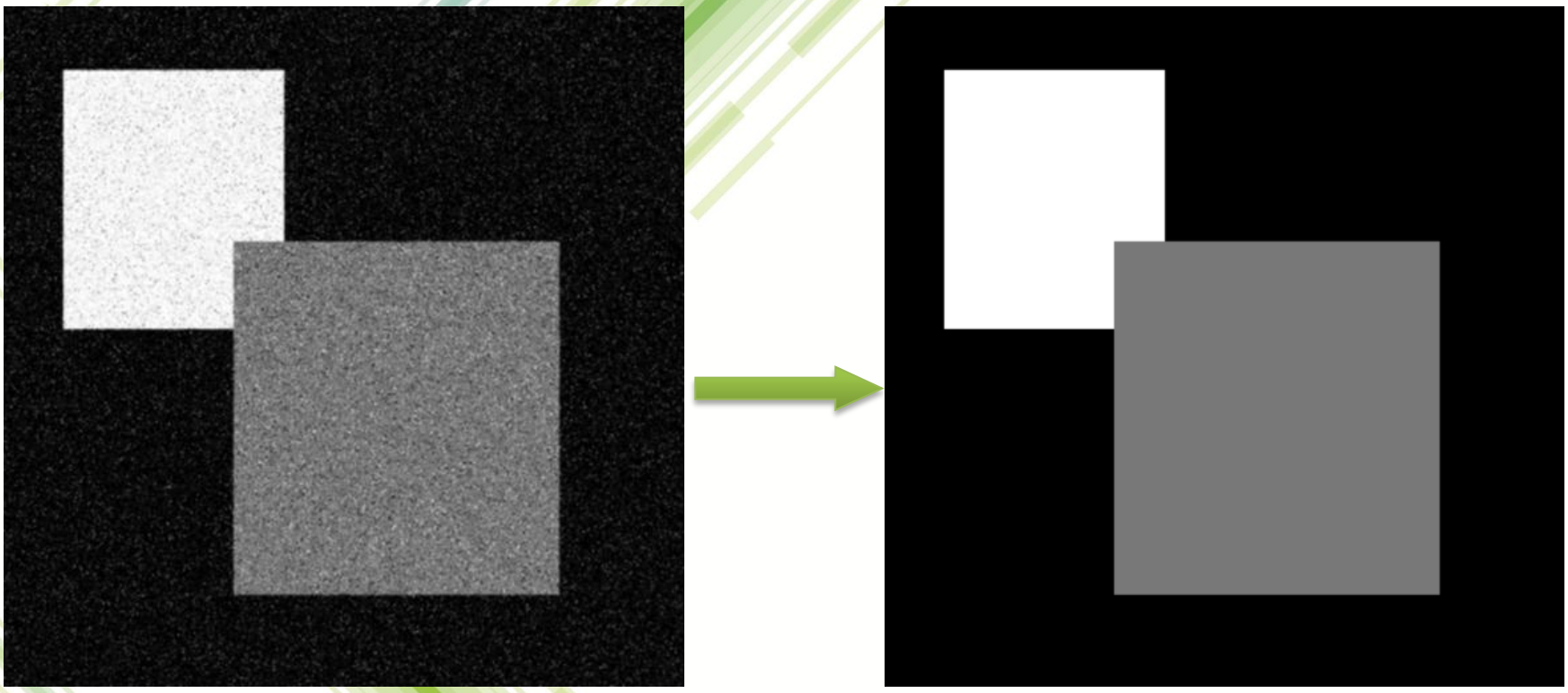
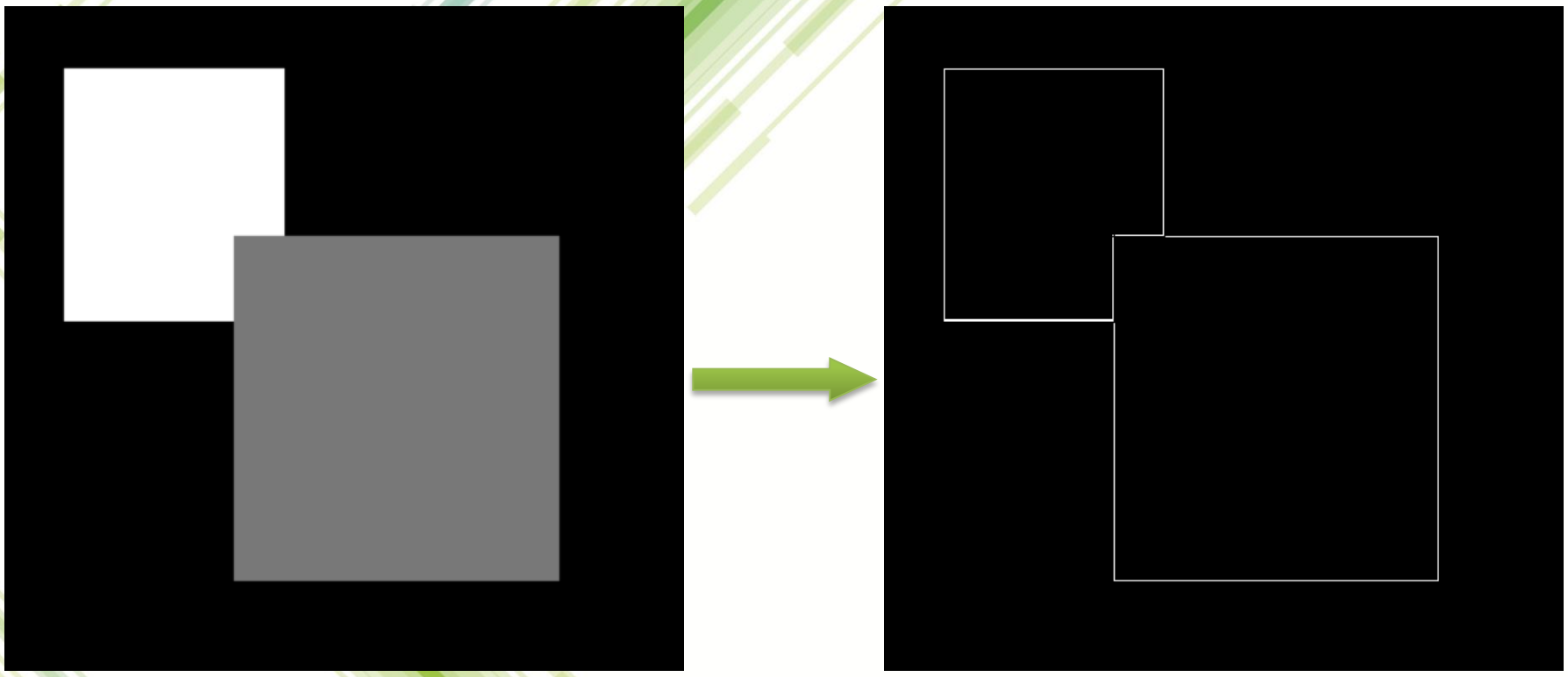


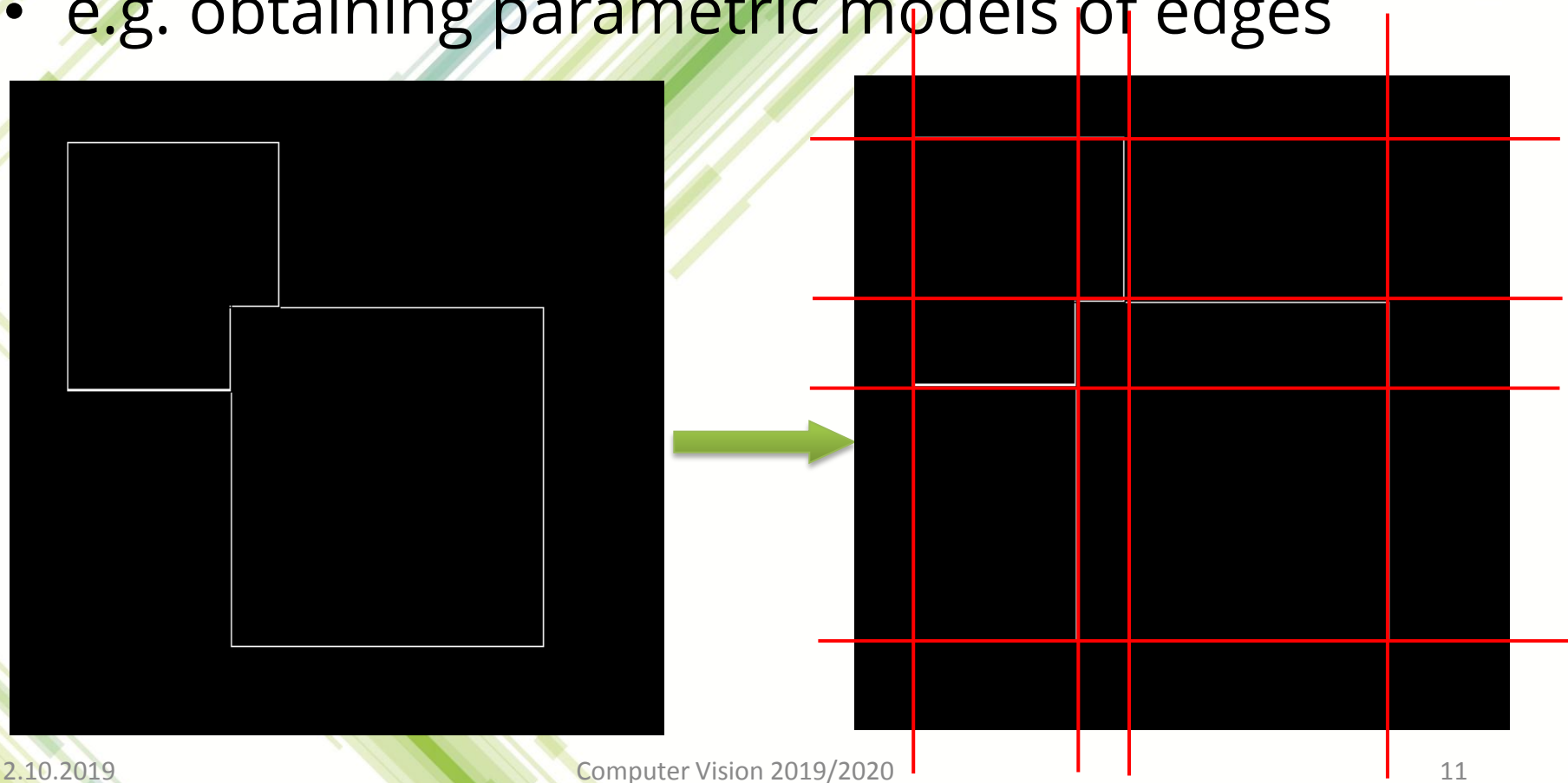
Image processing/analysis

- Purpose: to reduce amount of information
- e.g. edge extraction



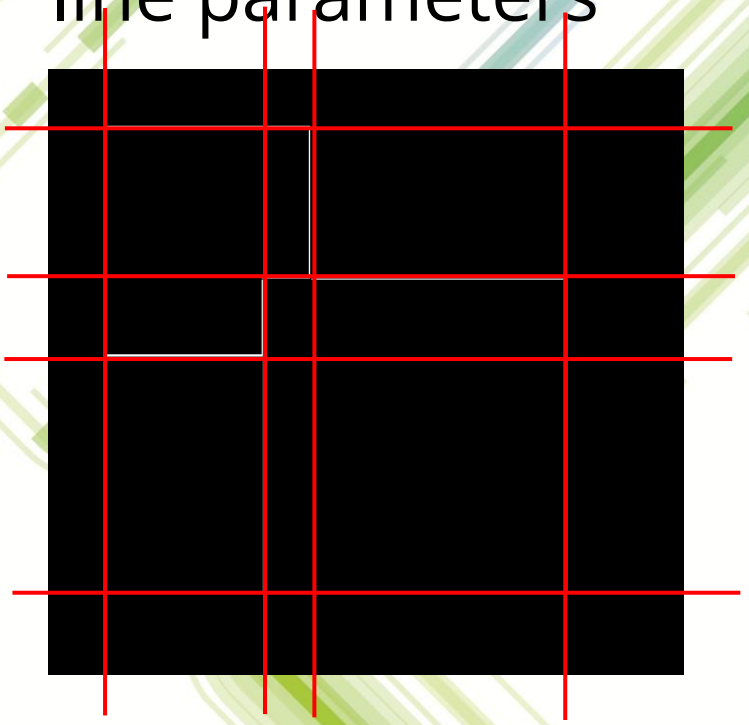
Feature extraction

- Purpose: to get condensed *useful* information
- e.g. obtaining parametric models of edges

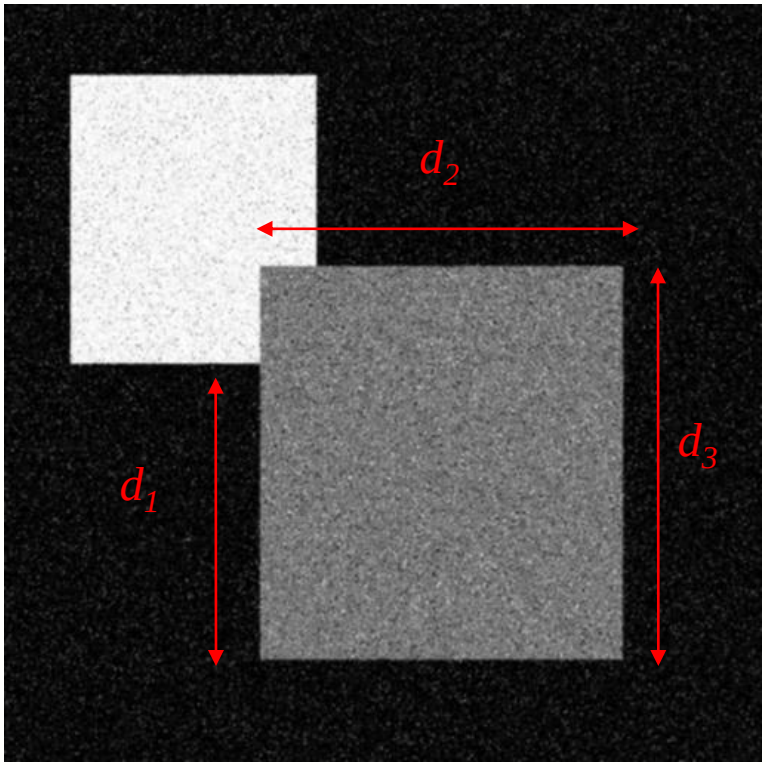


Generating scene description

- Example: calculating 2D measurements from line parameters



k1,k2,k3,k4,k5,k6,k7,k8
n1,n2,n3,n4,n5,n6,n7,n8



What is computer vision?

- Computer vision is
  - a scientific,
  - research,
  - technology field.

- What do you think? Is computer vision:
  - Mature engineering field?
  - Emerging engineering field?
  - Something in between?

Limits of computer vision

- Computer vision can solve *niche problems*
  - Meaning: useful for some applications, not for others
- It is widely used in manufacturing
  - Quality control (defect detection)
  - Optical measurements
  - All this under *carefully controlled conditions*
- Why would you use it then?
  - It is fully contactless measuring/observation method!

Origins of computer vision

- Marvin Minsky (1927-2016)
  - Co-founder of AI lab at MIT, won Turing award in 1969
  - Assigns “Computer vision” as an undergraduate summer student project in 1966
  - Goal is “to solve the computer vision problem”
  - What happened?

Early years of computer vision

Real-World Machines

A computer, a television camera, and a mechanical arm have now been combined into a system with enough artificial intelligence to recognize blocks of various sizes and shapes and to assemble them into structures without step-by-step instructions from an operator. The system can perceive the blocks visually, determining their size and their location on a table. It can stack them into a tower while accomplishing another goal, for example, of making the tower as high as possible with the given blocks. Or, it can be told to sort the blocks by size into neat, separate stacks.

Development of this kind of system, which was demonstrated at M.I.T. this spring, is an early stage of research on principles that will give machines engaged in routine tasks greater flexibility through their ability to see their work. Even simple vision would allow a machine to grasp one object without relying on its being absolutely positioned, or to pick up an object it had dropped, or to recognize defects.

Long range goals of work directed by Marvin L. Minsky, Professor of Electrical Engineering, and Seymour A. Papert, Visiting Professor of Applied Mathematics, envisage machines with finer and more varied visual abilities and more manual dexterity than are required for such semi-routine tasks. Work is progressing on binocular vision, color vision, the ability to perceive textures, touch sensors, improved mechanical hands and other areas whose development is necessary for accomplishing significant real-world tasks. Underlining goals such as these, especially the ability to program machines to acquire and use a substantial fund of knowledge about the real world, reveals the extent of scientific and engineering progress toward "artificial intelligence."

For vision, the system demonstrated at M.I.T. this spring uses "image dissector" cameras controlled by a computer to concentrate on any desired parts of the scene before them.

For arms, the project began with a standard industrial device designed for remote handling of hazardous materials. Now a very much more advanced arm has been developed for more complex tasks; with a shoulder and three elbows, it has eight movable joints and can reach around obstacles.

The programs that analyze the visual scene have to "know" a good deal about shapes of objects, about surface textures, shadows, perspective, lighting and other aspects of the working environments, especially about how to recognize objects that are partially covered by others. The programs must also be equipped with information about mechanical stability of structures, and with general principles of problem-solving. While there has been progress in mechanizing each of these, this system is the first attempt to put all this together into one system, and that in itself is one of the most difficult of its research objectives.

"Perhaps the central problem at the present time," says Professor Minsky, "is to increase the ability of computers to deal with mixtures of different kinds of information including general principles of problem solving. We do not like to predict how far artificial intelligence can be carried, using just the current stock

A computer, a television camera, and a mechanical arm have now been combined into a system with enough artificial intelligence being controlled by Professor Marvin L. Minsky ... In the picture, the camera is at the upper ... and the mechanical arm with a vise-like hand is ... holding a block to be stacked. The large-scale PDP-6 computer which is programmed to co-ordinate eyes and ... is located elsewhere in the laboratory.

of ideas and programming techniques. Sometimes a problem will seem completely insurmountable. Then someone comes up with a simple new idea, or just a rearrangement of old ideas, that completely eliminates it. The degree of intelligence that a man or a machine can show depends on many qualities of the ways that knowledge, goals, and problem-solving techniques are represented and put together, and not so much on the fine details."

A computer, a television camera, and a mechanical arm have now been combined into a system with enough artificial intelligence to recognize blocks of various sizes and shapes and to assemble them into structures without step-by-step instructions from an operator.

FROM THE ARCHIVES

The Tricky Challenge of Making Machines That "See"

A 1968 story from our archives takes a look at the early work in artificial intelligence by Marvin Minsky.

MIT Technology Review
July/Avg 1968

MIT Technology Review
30. okt 2015

Use of computer vision today

- Substantial progress has been made since 1960s
  - But perhaps nothing has been learned regarding the hype:

Says the journalist/investor

VOICES | SELF-DRIVING CARS | EMERGING TECH

Autonomous driving is here, and it's going to change everything

Welcome to the hands-free world.

Says the head of Google's autonomous driving program

Google Self-Driving Car Will Be Ready Soon for Some, in Decades for Others

By Lee Gomes
Posted 18 Mar 2016 | 14:28 GMT

Use of computer vision today

- Optical character recognition (OCR) to convert scanned docs to text
  - Widely used, works well
  - Below the sample of text segmentation

Husene er for det meste af træ. I bydelen omkring Sannesund er gaderne trange og krogede; bebyggelsen bestaar af smaa træhuse omkring den store S. melkefabrik (kondenseret melk) m. fl. fabriker. Her ligger ogsaa toldboden, dampskibsbryggen. I den nye bydel langs Glommens (Sarpfossens) vestbred de store bygninger for Borregaards fabriker. S. er en af Norges ældste byer. Den hed oprindelig Borg og anlagdes af Olav den hel-

med elektricitet fra Hafslunds elektricitetsverk ved Sarpfossen. Foruden folkeskole og kommunal høiere almenskole er der en teknisk aftenskole. To blade (‹Glommen› og ‹Sarpen›). Byen vælger én stortingsrepræsentant. Ved Smaalensbanen staar S. i forbindelse med Kra. (Se pl. Sarpsborg.) [Litt.: B. Christophersen, ‹S.s historie fra 1016› (1901); ‹Norges næringsliv. S. og omegn. Med indledning af N. S. Olsen› (1908).]

By LA2 - Own work, CC0, https://commons.wikimedia.org/w/index.php?curid=17709286

Use of computer vision today

- Manufacturing, process control
  - Assembly, positioning
  - Robot guidance
  - Sorting
  - Inspection for defects
  - Gauging
  - 1D, 2D code reading
  - Many more

Use of computer vision today

- Face detection, smile detection
  - As part of embedded devices (cameras, phones)

- Panorama stitching

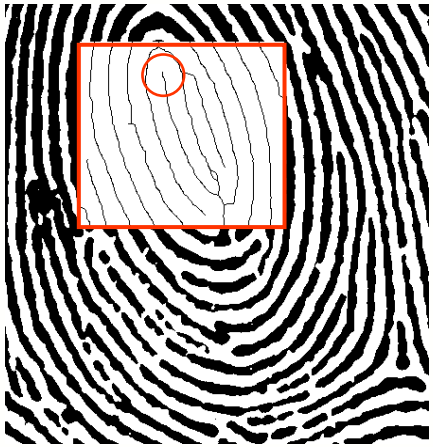
Use of computer vision today

- Entertainment
- Human-computer interfaces

Microsoft Kinect V2

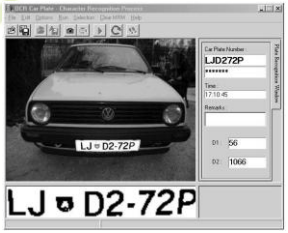
Use of computer vision today

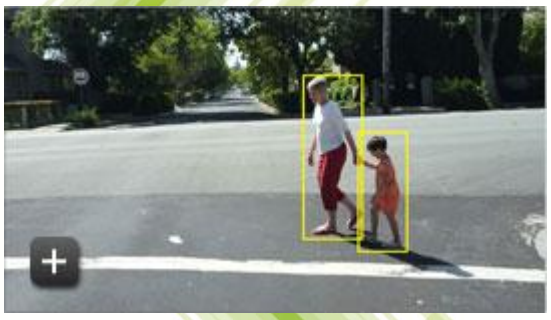
- Vision-based biometrics:
  - iris, face, fingerprint recognition



Use of computer vision today

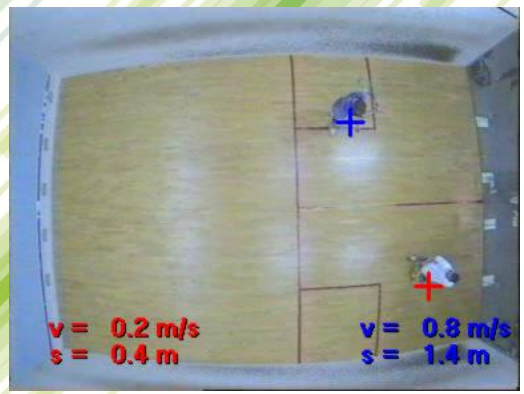
- Transportation, traffic control, automotive*
  - License plate recognition, speed control
  - Parking assistance
  - Night vision, pedestrain detection, traffic sign recognition, …

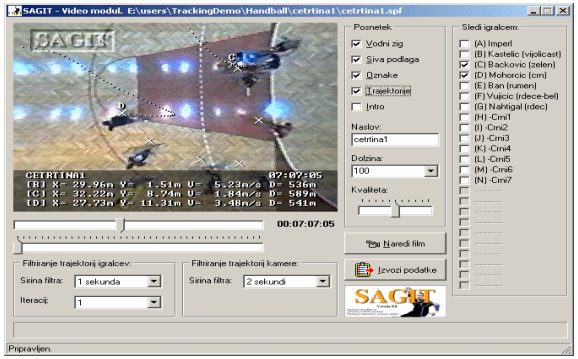


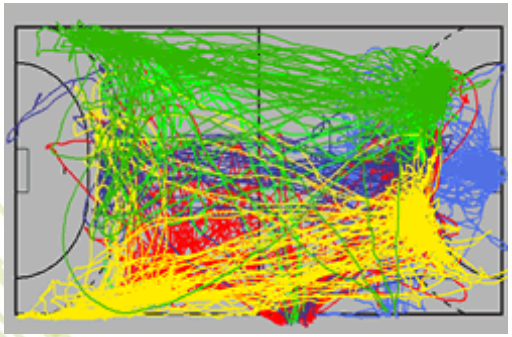


Use of computer vision today

- Sports
  - Load (and indirectly effort): trajectories, velocities
  - Skeleton motion





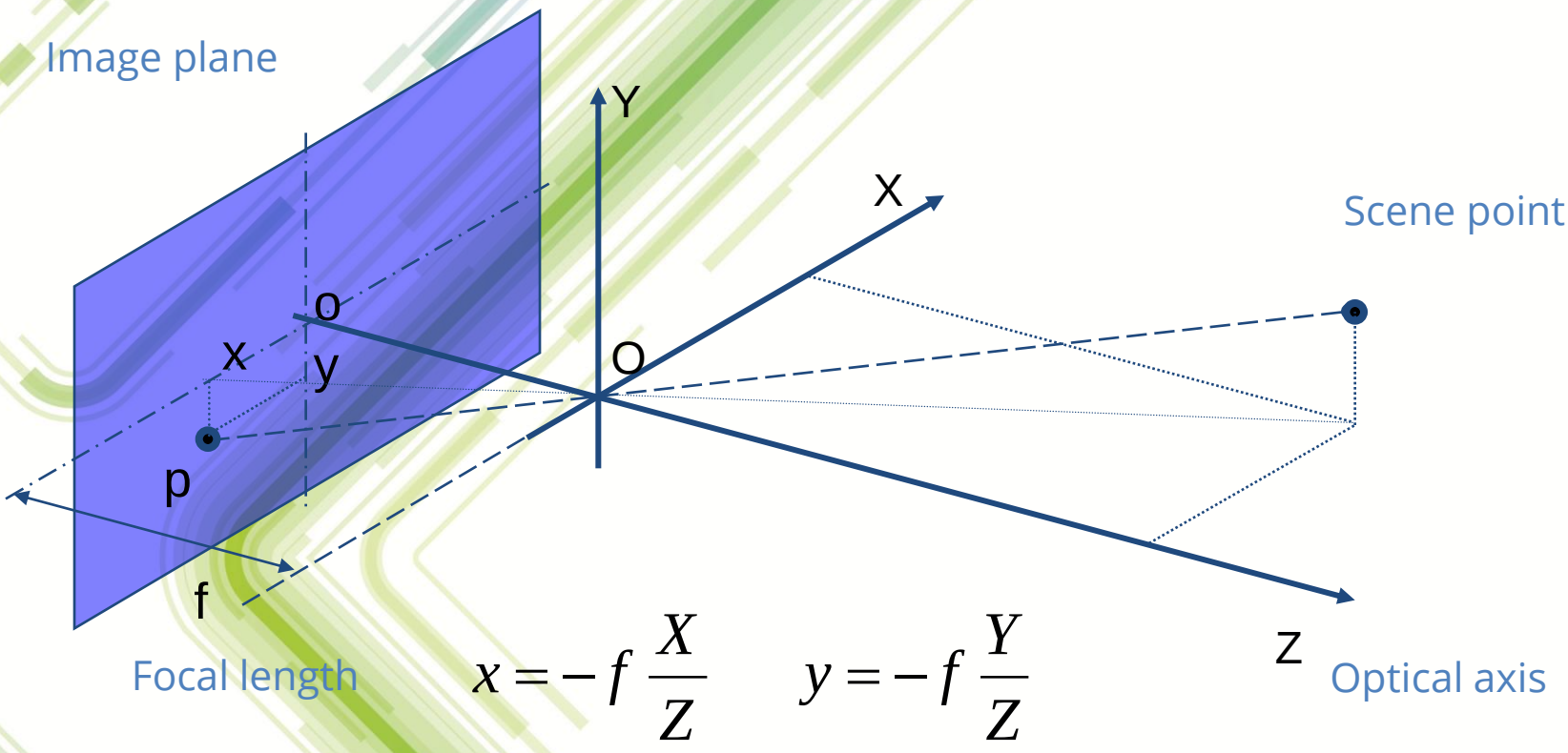


Computer vision vs. Machine vision

- Machine vision is more specific and application oriented
- It used to be:
  - Machine vision = industrial vision
  - but new application domains are on the horizon.
- Machine vision = whenever we design the WHOLE system
  - Lighting
  - Optics
  - Acquisition process
  - Algorithms

Next week

- Image formation



Questions?