Ti5213100 Introduction to Machine Vision and Machine Learning

PART I – MACHINE VISION:

Lecture 1: Practical Arrangements & Introduction and Motivation

Lecture 1 Contents

i. Practical arrangements

ii. Fundamental concept: Digital image

iii. Definition and description

iv. Motivation by current and future applications

v. Ultimate goal

vi. Parts of machine vision systems

vii. Visual information

i. Practical arrangements

- Course syllabus: prerequisities and content
- Course project
- Exam

ii. Fundamental concept: digital Image

- Discrete representation: a 2-D spatial image (matrix) consists of **pixels** (number of pixels defines image **resolution**)
  - Binary image
  - Gray scale image
  - Color image (RGB)

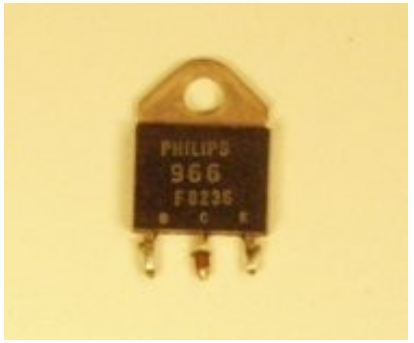
iii. Definition and description

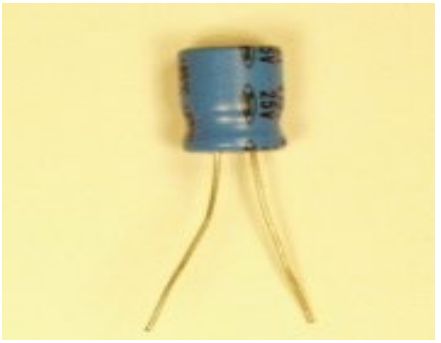
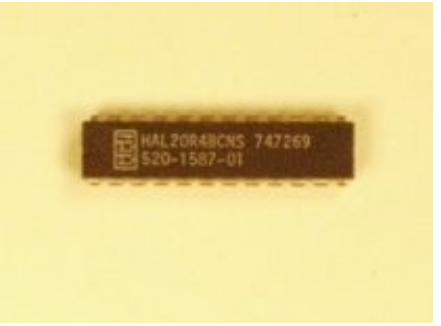
- Computer systems operating on *visual information* (images, image sequences) are considered as machine vision systems
- Typical machine vision (MV) system captures an image from a scene and “extracts” useful information (location of object, etc.) to be used in system actions (e.g., pick object)
- Existing and possible applications appear at all areas of science, health care, services, industry and defense

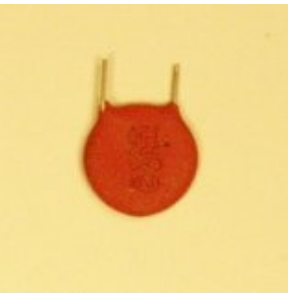
iv. Motivation by current and future applications

- Current applications are limited, but the future potential is enormous!

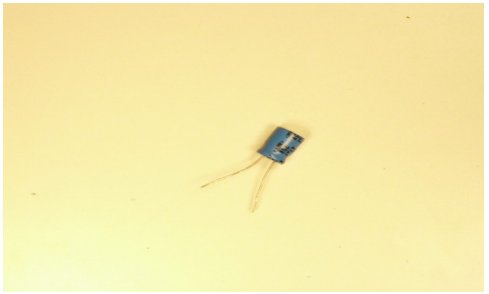
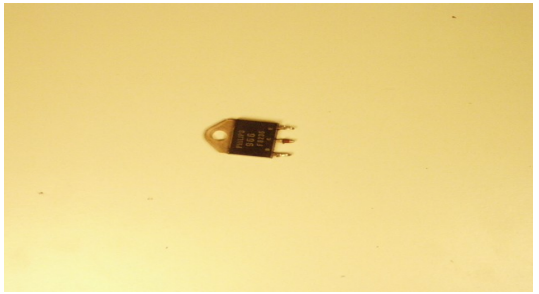
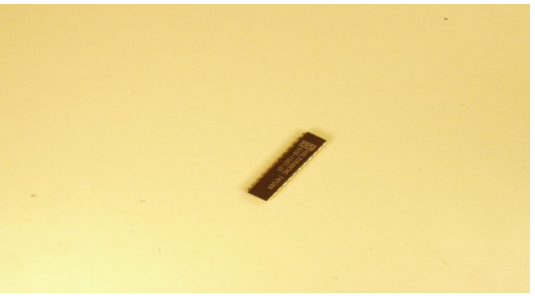
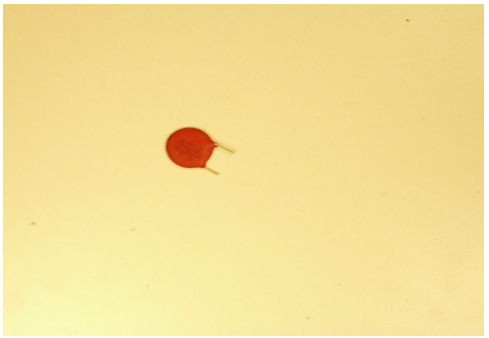
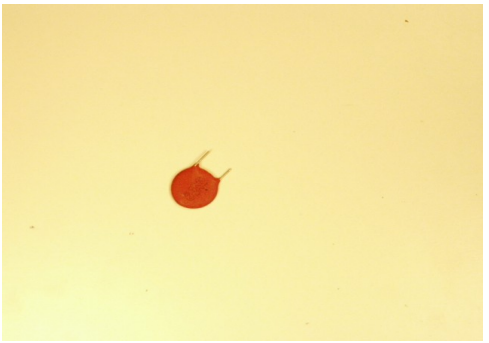
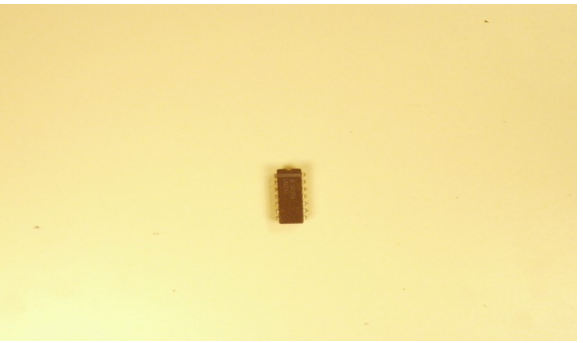
iv.1. Electric component detection and recognition





Locate an object - identify the object - give coordinates and pose

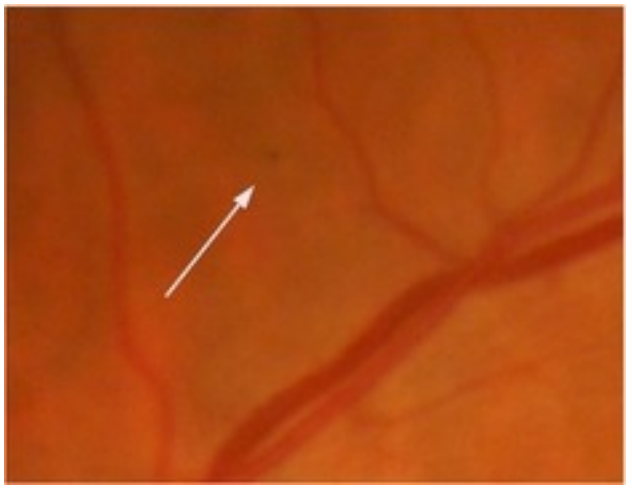
iv.2. Diabetes screening from retina images

- Currently done by radiologists or specialized medical doctors – expensive and laborous – no resources for broad screening

Retinal camera
[University of Kuopio]

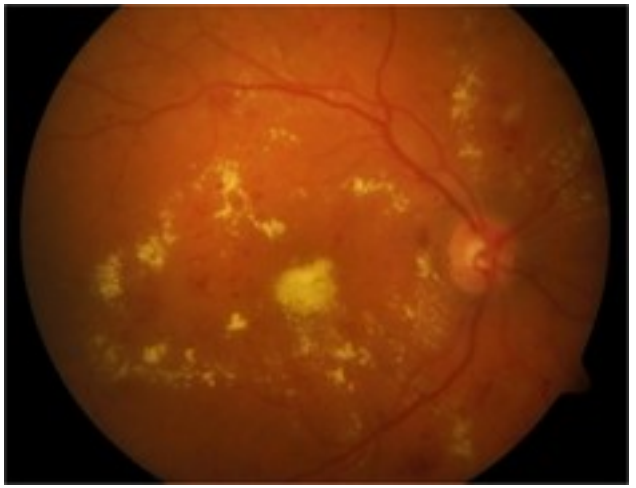
iv.2. Diabetes screening from retina images (*cont.)*

Examples of retinal diabetic findings

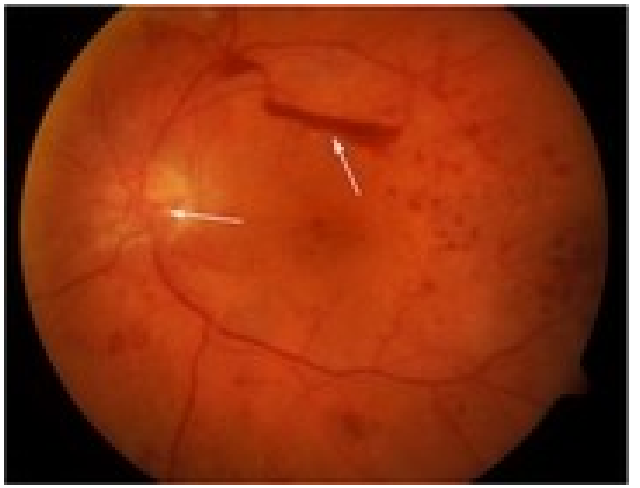


Small blood leaks

Large blood leaks



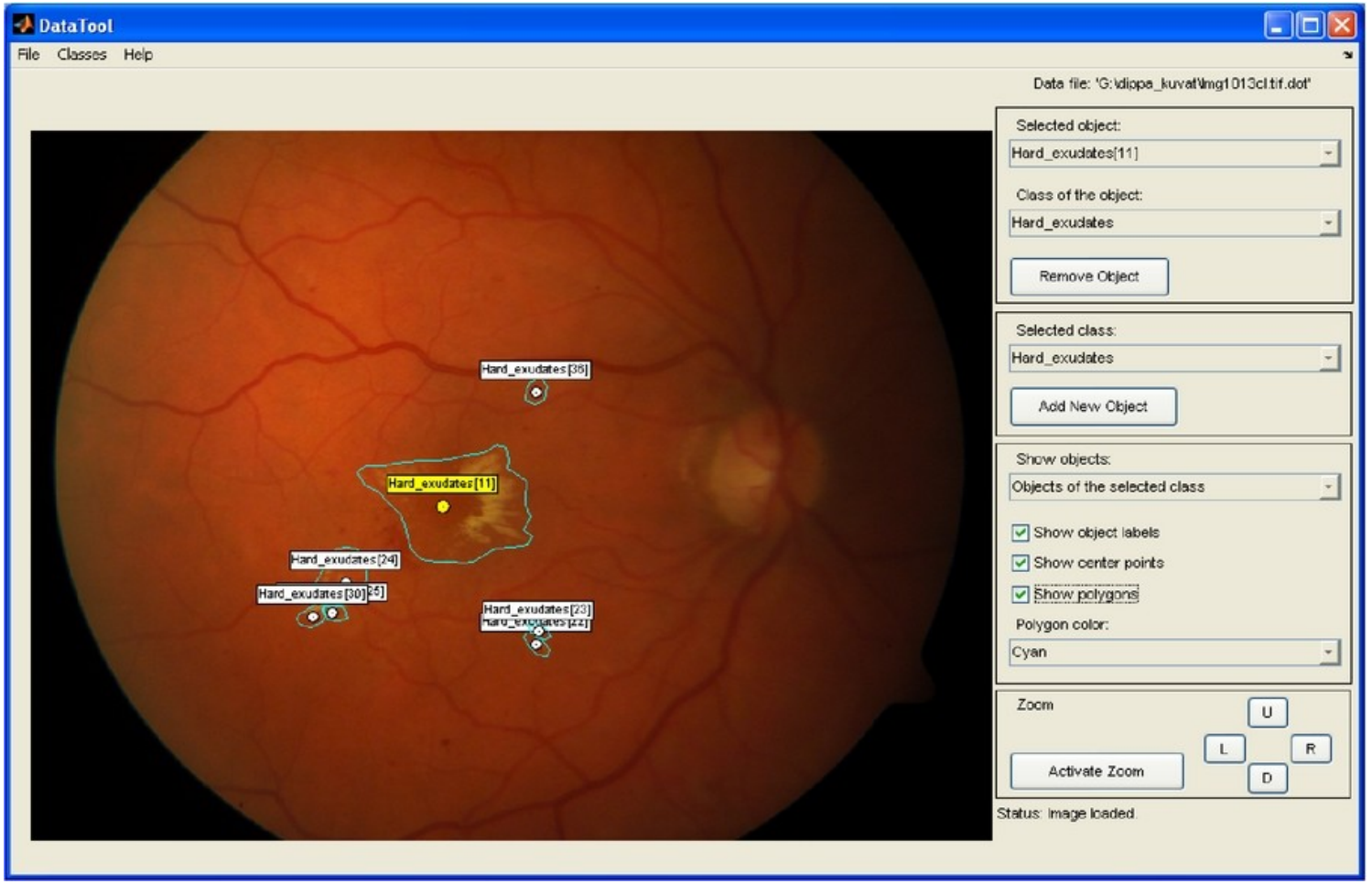
Fat leaks (exudate)



New vessels

iv.2. Diabetes screening from retina images (*cont.)*

- Early diagnosis can be made and fatal consequences avoided by automatic or assisting image analysis



iv.3. Face recognition

Automatically verify that person is who he claims to be

Identify persons in images (*watch list: "*Osama Bin Laden")

- New challenge: How to extract 3D face from a 2D image: *video: siggraph99.mpg*

iv.4. Active (robot) vision

- Visual information provides control information for active apparatus (“robot”)
  - Apparatus is able to track dynamic changes and interact with its environment
- Calibrated view required
  - Mapping from the image coordinates to the real coordinates
- Many industrial applications
- Active research area (*Video: RoboCup_G007_Humanoid_League.avi*)

v. Ultimate goal - when our work is done?

- Ultimate goal of artificial intelligence is “human kind robot”
  - Robots automatically learn and progress in their tasks
  - Robots are capable to assist human
  - Robots become “man kind” (*Video: t2-measure.avi*)
- Requires artificial vision and cognition which compare to human vision and cognition
  - Current sensor technologies already outperform human, but the artificial cognition is not in mature level
- Huge R&D work is still required
  - Industry needs educated engineers (Bsc, MSc, DSc)

vi. Parts of machine vision systems

- Converting visual appearance of a scene to a digital image requires expertise from many fields of science
  - Light physics and optics
  - Analog and digital electronics, and signal processing
- Converting the digital image to information requires expertise of artificial cognition
  - Mathematics, computer science and pattern recognition

vii. Visual information

- Machine vision can be seen as a task of processing visual information (2-D)

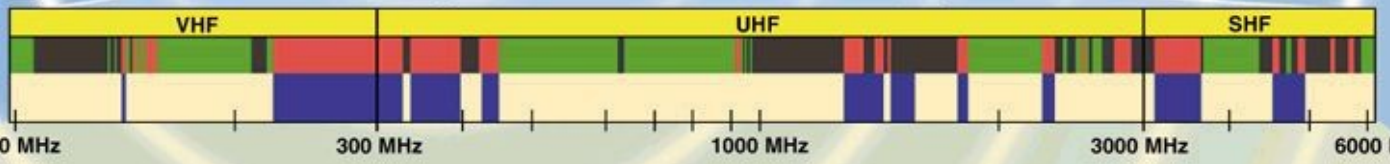
Electromagnetic Spectrum

THE RADIO SPECTRUM

- Non-Federal Controlled Spectrum (30.4%)
- Federal Controlled Spectrum (31.6%)
- Shared Spectrum (38.0%)
- Selected Bands at Issue

Below 6 GHz

The top bar shows how the electromagnetic spectrum is divided into various regions, and indicates that portion referred to as the Radio Spectrum. The lower bar illustrates the division of Federal, Non-Federal, and Shared bands for a critical part of the Radio Spectrum. Also shown are selected military uses that would be impacted by reallocating spectrum for competing commercial use.



Selected Bands at Issue

138 - 144 MHz

Military Uses	Competing Uses
Land Mobile Radio	Little LEOs
Tactical Air / Ground / Air	Public Safety

225 - 400 MHz

Military Uses	Competing Uses
Tactical Air / Ground / Air	Little LEOs
Data Links	Public Safety
Satellite Comm	Terrestrial DAB
Military ATC	CMRS
Search & Rescue	Space Research
Executive Comm	
Tactical Comm	

400.15 - 401 MHz

Military Uses	Competing Uses
DMSP (↓)	MSS

420 - 450 MHz

Military Uses	Competing Uses
BM Surveillance and Early Warning Radars	Auxiliary Broadcast
Shipboard / Airborne Early Warning Radars	CMRS
Missile / Air Vehicle Flight Termination	Biomedical Telemetry
Troop Position Location	WLL
Anti-Stealth Radar	MSS
Foliage Penetration Radar	EES (active)

1215 - 1390 MHz

Military Uses	Competing Uses
Long / Medium Range Air Defense	MSS
Radio Navigation	NLMCS
Air Route Surveillance Radars	Wind Profiler Radars
Tactical Communications	
Test Range Support	
Air / Fleet Defense	
Drug Interdiction	
GPS	
Remote Satellite Sensors	
Nuclear Detection	

1435 - 1525 MHz

Military Uses	Competing Uses
Telemetry Supporting Entire Aerospace Industry	DAB / DARS
	MSS
	NLMCS

1755 - 1850 MHz

Military Uses	Competing Uses
DoD Satellite TT&C (↑)	PCS
Point-to Point Microwave	MDS
Air Combat Training Systems	3G Wireless / IMIT 2000
Tactical Comm	
Tactical Data Links	

2200 - 2290 MHz

Military Uses	Competing Uses
DoD Satellite TT&C (↓)	PCS
Guided Missile Telemetry	MDS
Point to-Point Microwave	WLL

3100 - 3650 MHz

Military Uses	Competing Uses
High Power Mobile Radars	MDS
Shipboard ATC	WLL
Missile Links	FSS
Airborne Station Keeping	

4400 - 4940 MHz

Military Uses	Competing Uses
Fixed Wideband Comm	GWCS
Mobile Wideband Comm	FSS
Command Links	Public Safety
Data Links	

ATC -	Air Traffic Control
BM -	Ballistic Missile
CMRS -	Commercial Mobile Radio Service
DAB -	Digital Audio Broadcast - Terrestrial
DARS -	Digital Audio Radio Service - Satellite
DMSP -	Defense Meteorological Satellite Program
FSS -	Fixed Satellite Service
GPS -	Global Positioning Satellite
GWCS -	General Wireless Communications Service
IMT 2000 -	3rd Generation Mobile Telephony
LEO -	Low Earth Orbit
MDS -	Multipoint Distribution System
MSS -	Mobile Satellite Service
NLMCS -	New Land Mobile Communications Service
PCS -	Personal Communications Service
TT&C -	Tracking, Telemetry and Command
WLL -	Wireless Local Loop

DoD Joint Spectrum Center

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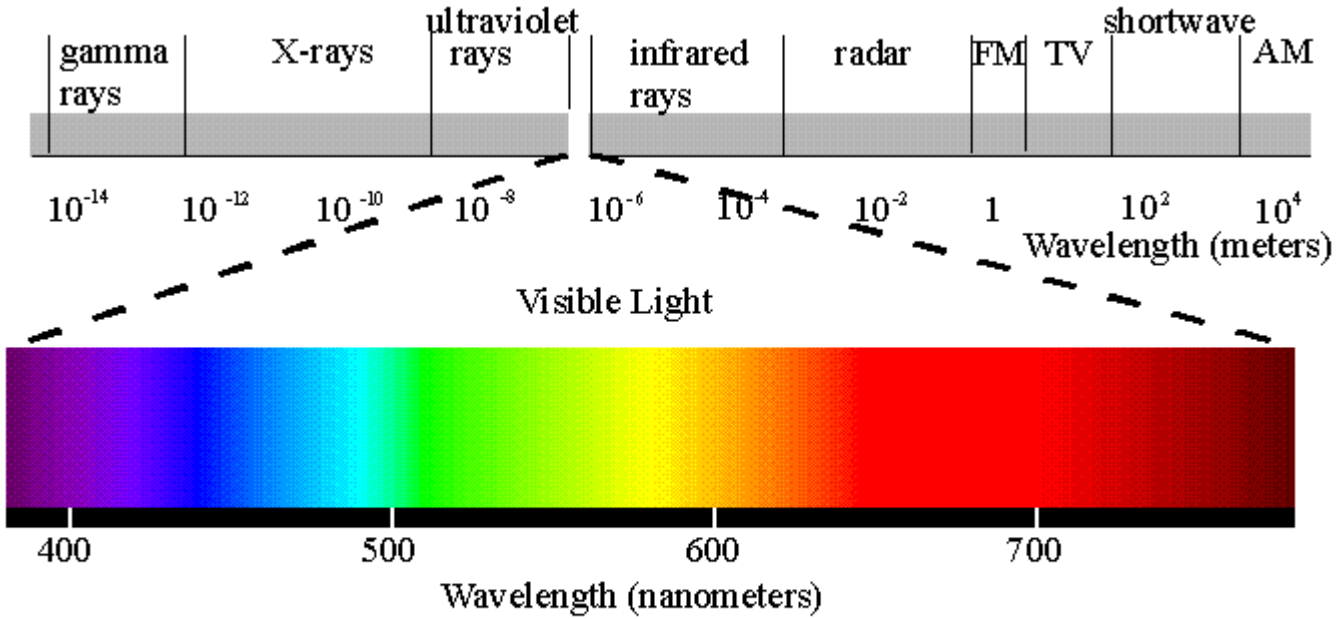
Vii.2. Wavelengths and color



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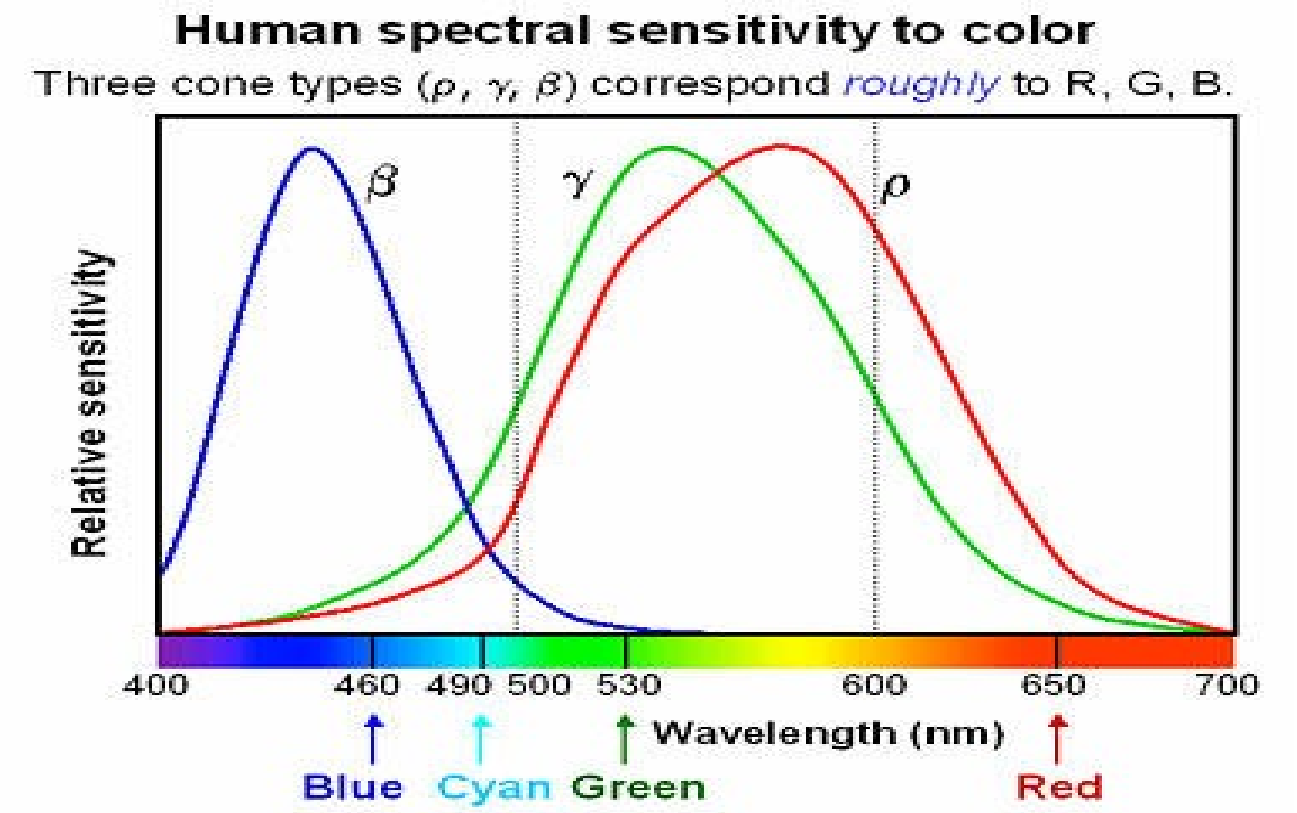
Vii.3. Photoreceptor cells



Lecture 1 – Conclusions

- The application potential of machine vision is enormous
  - “I understand what can be done, but I don’t understand how?” - “Please master, teach me how to use the Force!”
- The fundamental structure and work flow of MV systems is simple, but we have to study many fields of science in order to completely reveal its full power
  - “Future cannot be predicted, but it can be invented!”