Disclaimer

This summary is part of the lecture "ETH Image Analysis & Computer Vision" by Prof. Van Gool, Prof. Konukoglu and Prof. Goksel (HS19). It is based on the lecture.

Please report errors to doberm@student.ethz.ch such that others can benefit as well.

The upstream repository can be found at https://github.com/mrrebod/Summaries

Image Analysis & Computer Vision

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1 Introduction

Vision is important:

- Half our brain is devoted to it
- Developed many times douring evolution
- It is non-contact
- It can be implemenmted with high-resolution
- Works with ambient EM-waves
- yields color, texture, depth, motion, shape

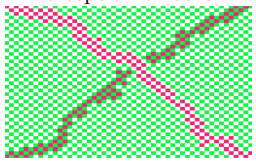
Take home message:
For people vision is their most crucial sense, for good reason

1.1 Perception of vision

Perception of **intensity**

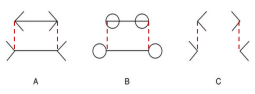
The gray fields have the same intensity (same gray tone).

Perception of **color**



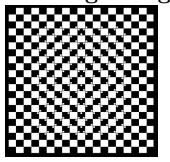
The red squares have equal color

Perception of **length**



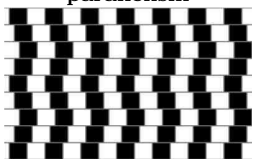
the horizontal lines are equally long.

Lines being straight



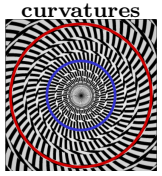
The lines do not have any curvature

Perception of **parallelism**



All lines are parallel.

Perception of **curvatures**



There is no spiral.

Perception of **motion**

The pole rotates about the vertical, it does not translate vertically.

The role of **context**

All encircled patterns are identical!

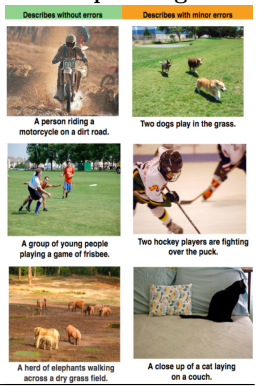
Take home message:
Effective vision needs more than sheer filtering and measuring

1.2 Applications

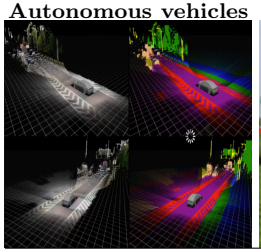
Most early applications where found in **production environments**, as these allow for **controlled conditions** and have **little uncertainty**. But some areas do not allow for much control: medical IP, remote sensing, surveillance, etc.
Currently Computer Vision (CV) is conquering the less controllable areas by storm:

Image enhancement:
mobile → DSLR

Image retrieval, captioning

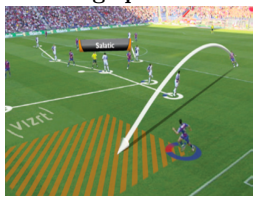


Autonomous vehicles



Visual surveillance

Augmented Reality, e.g sports



Computer-assisted surgery

Take home message:
It is feasible now to let most things see and interpret their environment.

1.3 The nature of light

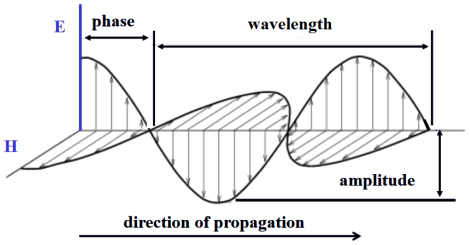
There are three different models to describe optical systems:

1. Geometrical optics
2. Physical optics → **wave character**
3. Quantum-mechanical optics

In this course we mainly look at physical optics and the wave character of light.

1.3.1 Light as EM-waves

Self-sustaining exchange of electric and magnetic fields. An EM-wave is characterized with the following properties:

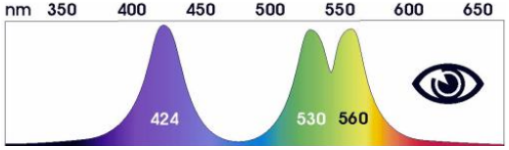


- **Wavelength**
- Direction of **propagation**
- **Amplitude** of E
- **Phase**
- Direction of **polarization**

The spectrum:
Normal ambient light is a mixture of wavelengths, polarization directions and phases. The visible range for humans is only a small fraction of the EM-waves-spectrum.

Wavelength $[nm]$		Color
380 - 450	→	violet
450 - 490	→	blue
490 - 560	→	green
560 - 590	→	yellow
590 - 630	→	orange
630 - 760	→	red

The visible range differs from humans to animals and also cameras may have different spectral sensitivities. There are also cameras for non-visible light such as infrared. The following picture shows the three color cones humans have and their sensitivity range:



1.3.2 Interactions with matter

We look at the following types of interaction with matter:

1. **Absorption**
   → blue water
2. **Scattering**
   → blue sky
   → red sunset
3. **Reflection**
   → colored ink
4. **Refraction**
   → dispersion by a prism
5. **Diffraction**

We look at few of those in more detail:

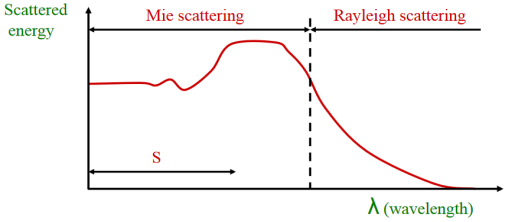
2. Scattering
There are three types of scattering depending on the relative sizes of particles and wavelengths:

(a) Small particles: **Rayleigh** (strong wavelength dependent)

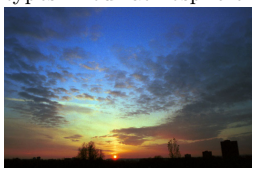
(b) Comparable size: **Mie** (weakly wavelength dependent)

(c) Large particles: **Non-selective** (wavelength independent)

If we look at the scattered energy it looks as follows:



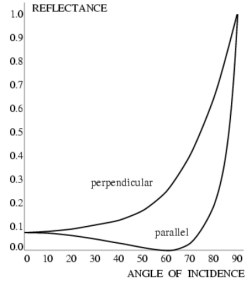
Let's see some examples of these different scatter-types in our atmosphere:



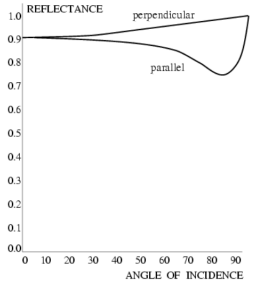
Rayleigh: Tyndall effect (blue sky, red setting sun)
Non-selective: Grey clouds

Mie: Colored cloud from volcanic eruption

3. Reflection:
In mirror reflection we have: angle of reflection = angle of incident.
Two different categories of reflective materials:



Dielectric:
For parallel polarization there exists the Brewster angle where $r = 0$.



Conductor:
Strong reflectors under all angles, more or less preserve polarization.