COMP3005: Computer Vision

Building machines that see

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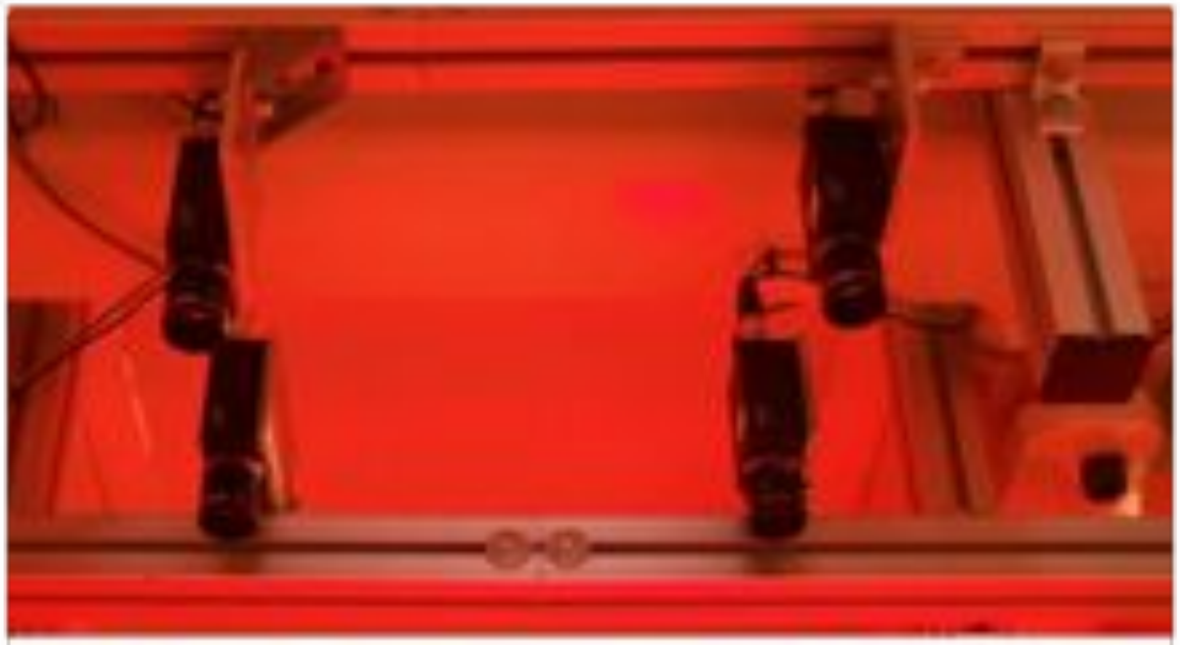
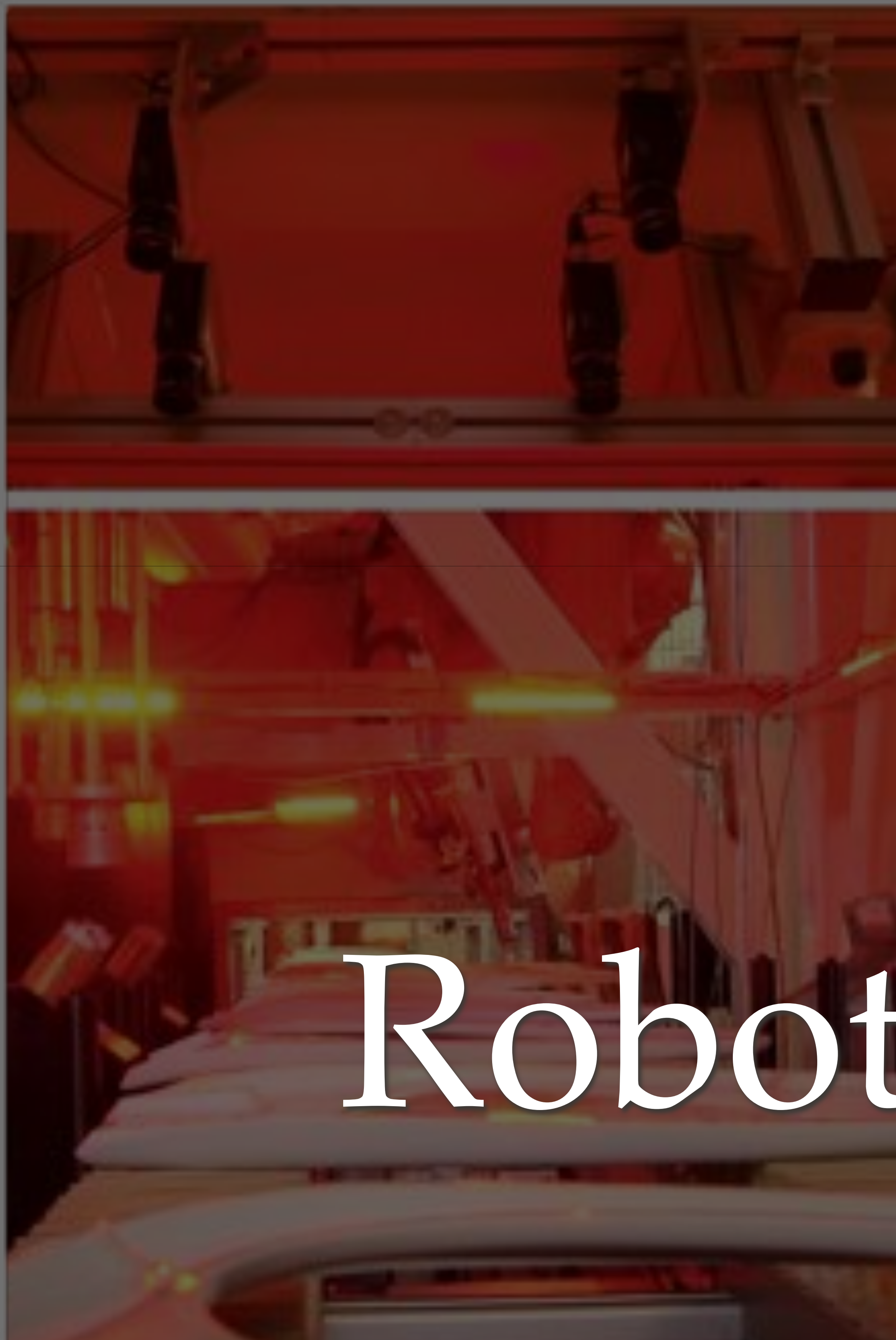
Types of Computer Vision and their **Environment**




Scanning
Madame X - Madame Pierre Gautreau
This artwork is not on display
Description

Industrial Vision

Robot Vision



Vision in the wild

What do all these systems have in common?

Computer Vision Software

Image Acquisition Hardware

but how do you go about designing a computer vision system? and is that all you need?

Key terms in designing CV systems

robust

invariant

repeatable

constraints

Key terms in designing CV systems

robust

invariant **repeatable**

These are what you want

constraints

Key terms in designing CV systems

robust

invariant **repeatable**

This is what you design your system to be

Key terms in designing CV systems

robust

This is what you apply to make it work

constraints

Robustness

- The vision system must be **robust** to changes in its environment
  - i.e. changes in lighting; angle or position of the camera; etc

Repeatability

- **Repeatability** is a *measure* of robustness
- Repeatability means that the system must work the same over and over, regardless of environmental changes

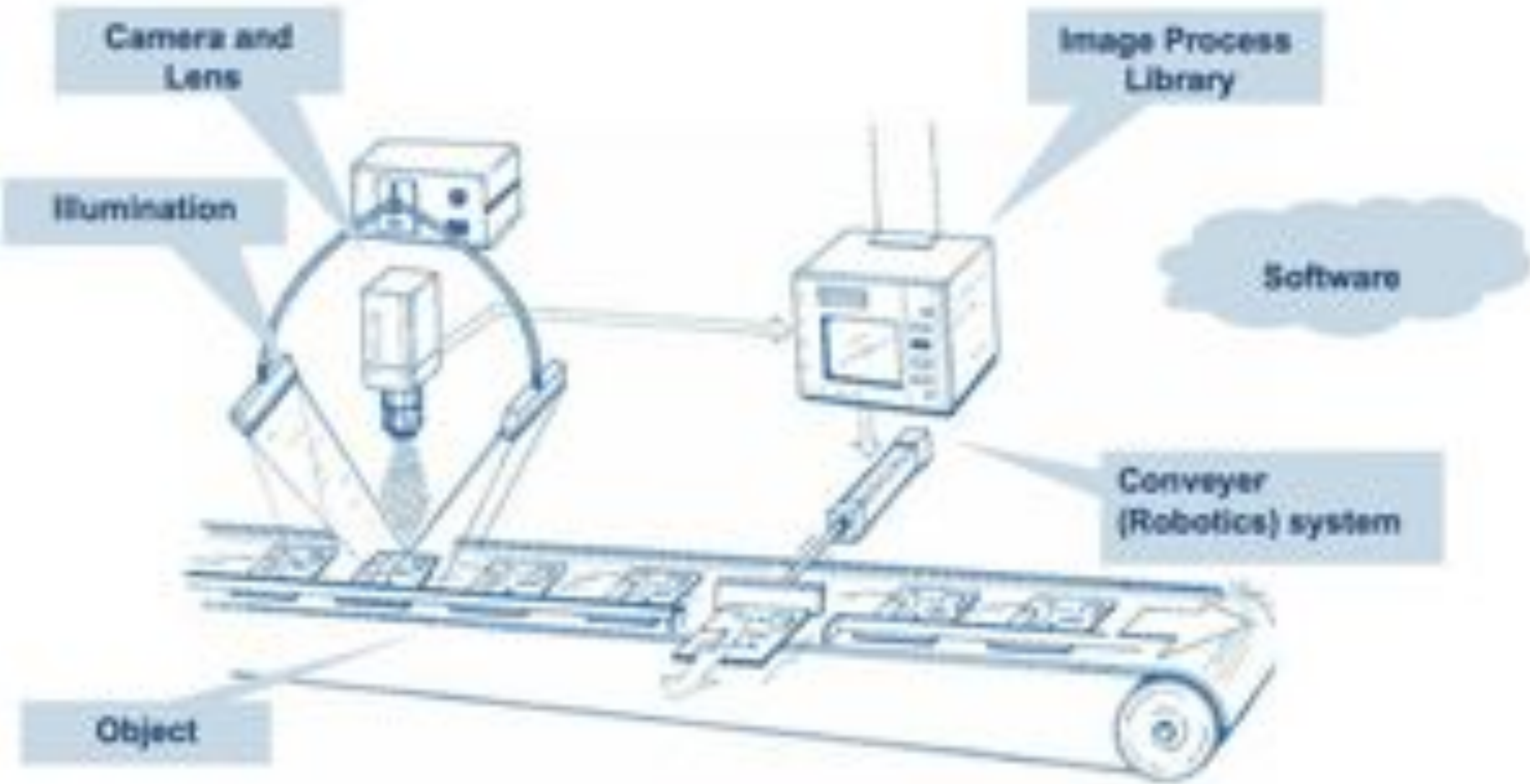
Invariance

- **Invariance** to environmental factors helps achieve robustness and repeatability
    - Hardware and software can be designed to be invariant to certain environmental changes
        - e.g. you could design an algorithm to be invariant to illumination changes…

Constraints

- **Constraints** are what you apply to the hardware, software and wetware to make your computer vision system work in a repeatable, robust fashion.
  - e.g. you constrain the system by putting it in a box so there can't be any illumination changes

Constraints in Industrial Vision


Camera and Lens
Image Process Library
Illumination
Software
Conveyer (Robotics) system
Object

Software Constraints

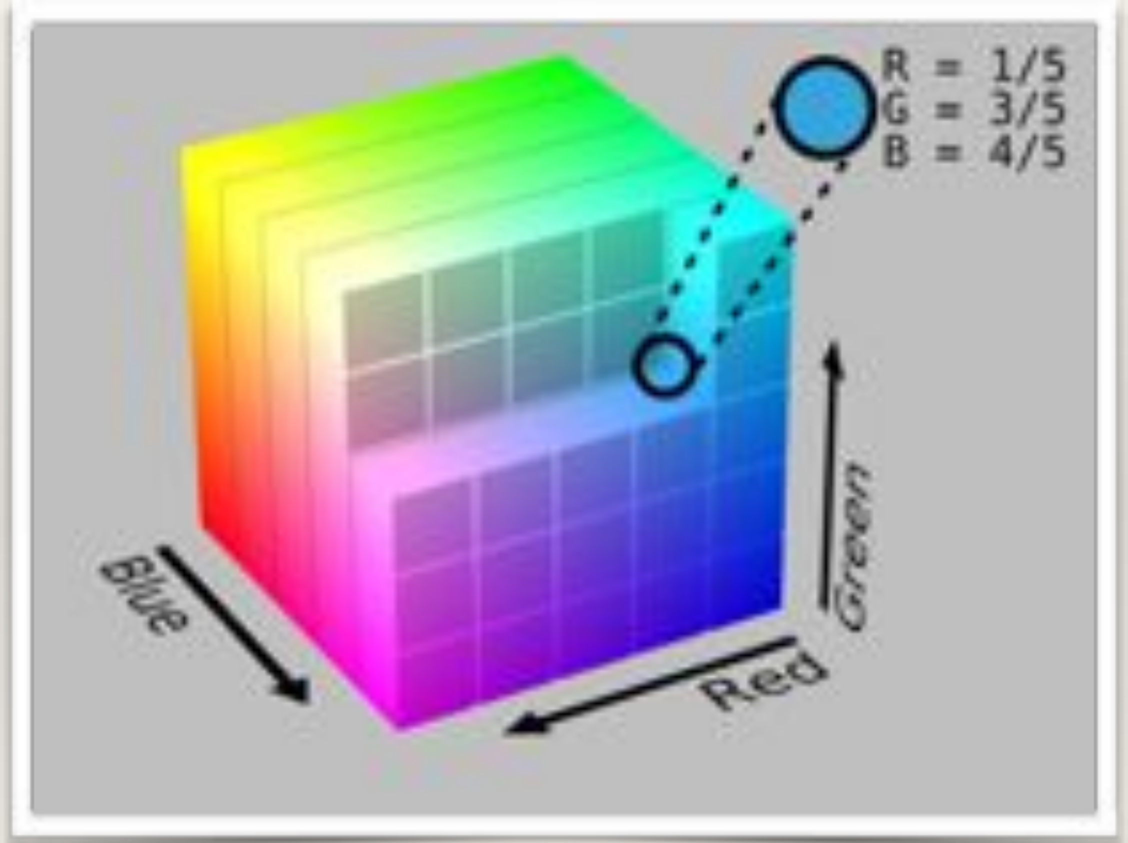
- **Really simple**, but **incredibly fast** algorithms
  - Hough Transform is popular, but note that it isn't all that robust without physical constraints
    - Actually, same is true of most algorithms / techniques used in industrial vision
  - Intelligent use of colour…

Important aside: Colour-spaces

- There are many different ways of *numerically* representing colour
  - A single representation of all possible colours is called a colour-space
  - It's *generally* possible to convert to one colour-space to another by applying a mapping (in the form of a set of equations or an algorithm)

RGB Colour-space

- Most physical image sensors capture RGB
  - By far the most widely known space
  - RGB "couples" brightness (luminance) with each channel, meaning that illumination invariance is difficult.



HSV Colour-space

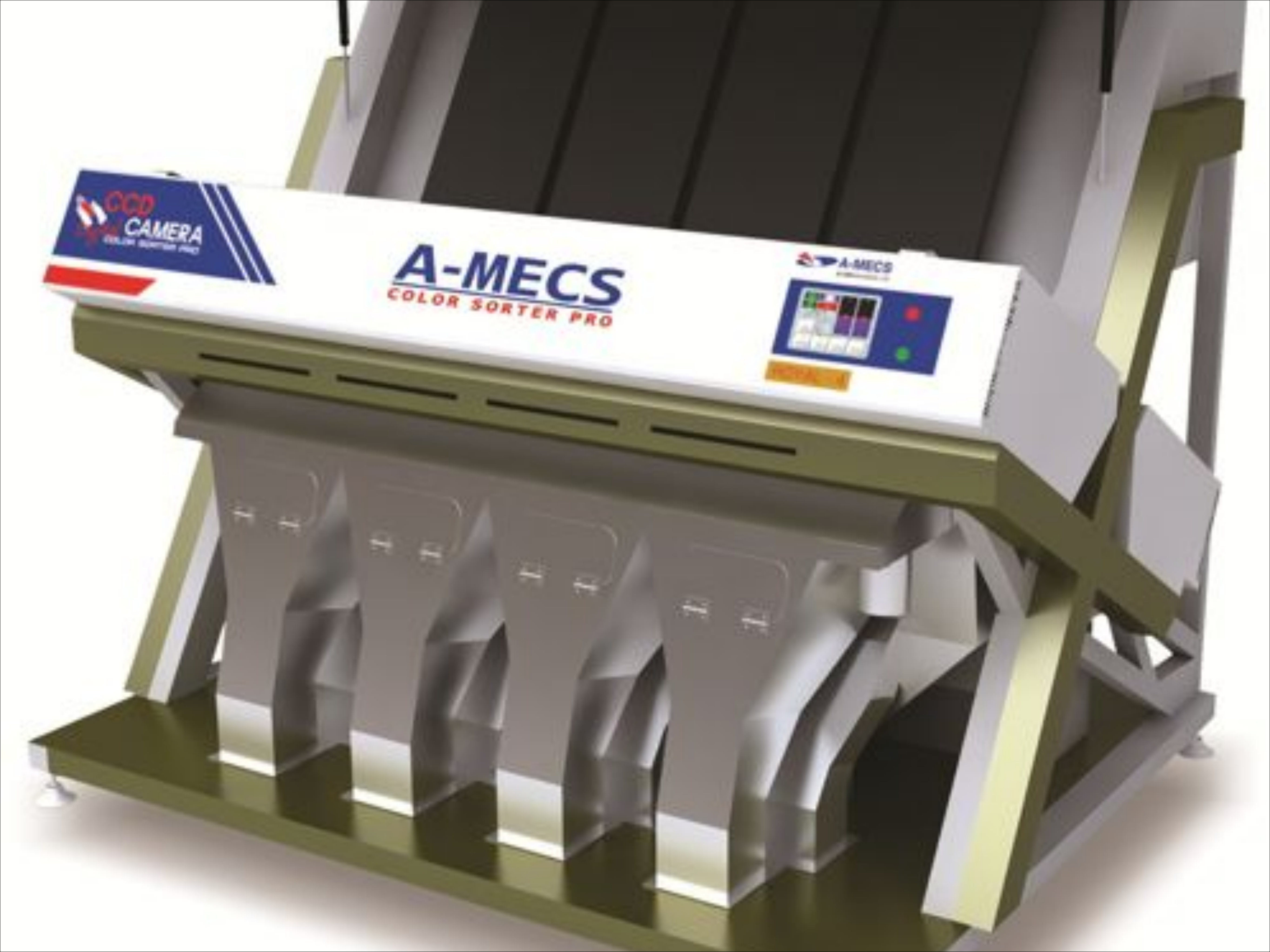
- Hue, Saturation, Value is another colour-space
  - Hue encodes the pure colour as an angle
    - **red == 0º == 360º !!**
  - Saturation is how vibrant the colour is
  - And the Value encodes brightness
  - A simple way of achieving invariance to lighting is to use just the H or H & S components

Demo: colour-spaces

Physical Constraints

- Industrial vision is usually solved by applying simple computer vision algorithms, and lots of physical constraints:
  - Environment: lighting, enclosure, mounting
  - Acquisition hardware: expensive camera, optics, filters

Let’s look at some types of physical constraint


CCD
CAMERA
COLOR SORTER PRO
A-MECS
COLOR SORTER PRO
A-MECS

Vision in the wild

- So, what about vision systems in the wild, like ANPR cameras, or recognition apps for mobile phones?
  - Apply as many hardware and wetware constraints as possible, and let the software take up the slack
  - Colour information often less important than luminance

ANPR constraints

- License plate styles are different across the world, so most ANPR systems will only work with plates from a single country.
- License plates themselves are constrained in design:
    - Dimensions
    - Font
    - Material (IR reflectance!)

Mobile vision constraints

- QR-Codes are designed to be robust
- But most software requires (constrains) the user to operate in a certain way:
  - Orientation - approximately upright
  - Within a certain area
  - Approximately stationary

Almost unconstrained vision?

- As computers become more powerful, and new software techniques are developed to deal with invariance the need for constraints becomes less.
- …but there is always going to be a problem of optimising the costs, and constraints can always help reduce costs

Summary

- **Robust** and **repeatable** computer vision is achieved through engineered **invariance** and applied **constraints**.