Robotics, Vision, and Mechatronics for Manufacturing

5-Light, Color, and Imaging

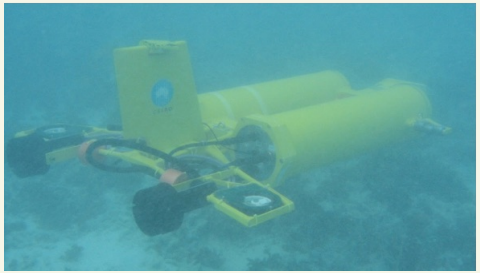
Xu Chen
Spring 2021

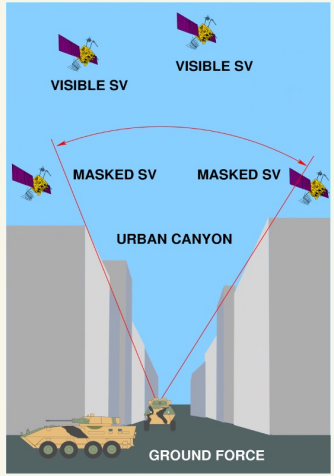
Introduction

Recall: “Robot: A goal-oriented machine that can sense, plan and act.”

To achieve the goal, the robot needs to know:
* where am I?
* where are you?
* how do I get there?

GPS is not perfect:
* Satellites are obscured in urban areas
* Not available in many important work domains such as
    - underwater
    - underground
    - deep forest
* Only tells “where am I”





Benefits of the vision system:

detects motions faster than the body can turn

200 frames/sec
360 deg vision
80% brain for sight
best vision among insects

visual acuity exceeds by a factor of ten that of dragonflies

jumping spider

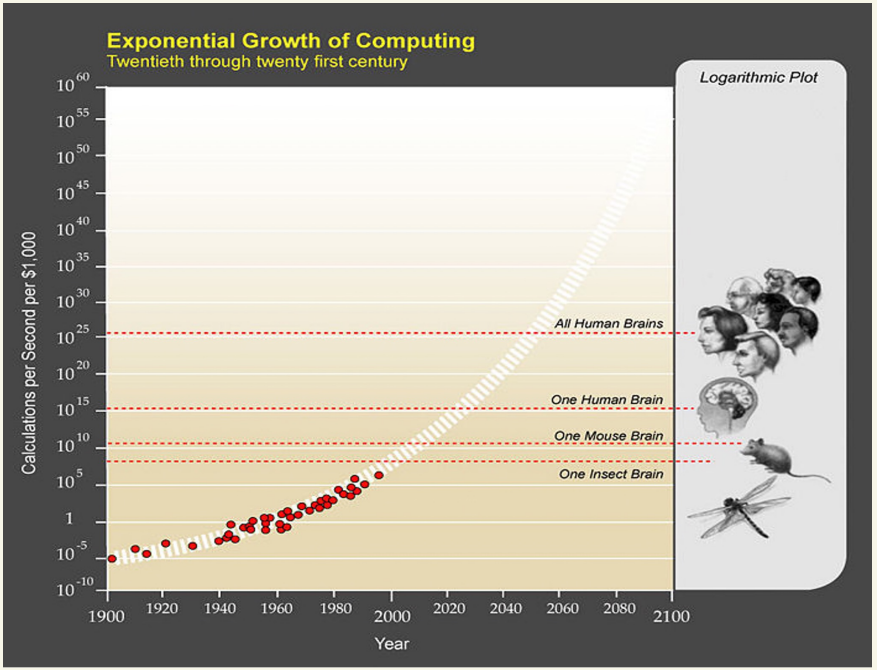
underwater

night vision

It takes a lot to reach the current status of vision systems in nature.

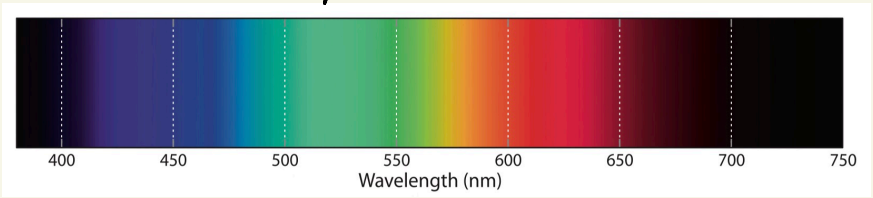
human brain:
1.5 kg
10^11 neurons
~1/3 for vision

540 million years ago



Light and Color

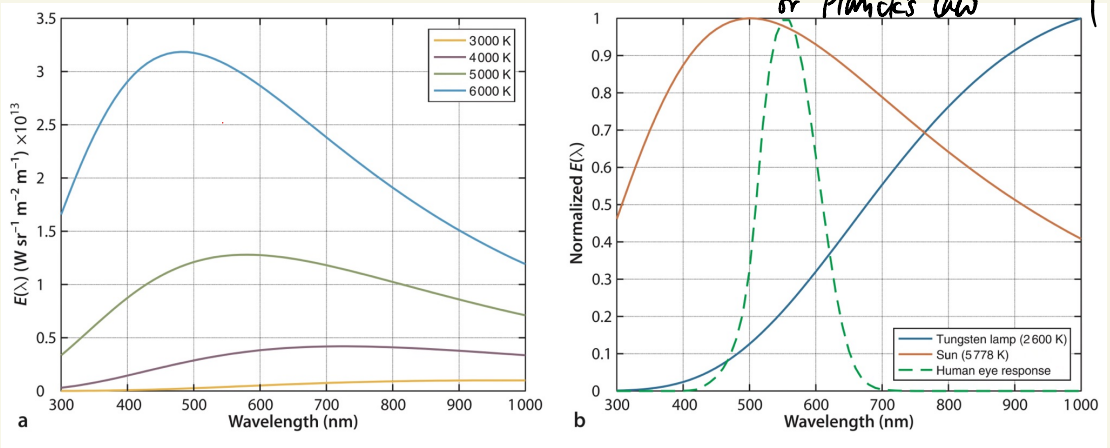
* the light we observe is a mix of electromagnetic waves at different frequencies/wavelengths
* the visible light spectrum: 400nm - 700 nm



* wavelength v.s. intensity map: $\lambda \sim E(\lambda)$ e.g. from a hot body

blackbody radiation or Planck's law $\frac{2hc^2}{\lambda^5\left(e^{\frac{hc}{\lambda kT}}-1\right)}$

c: speed of light
T: absolute temp (K) of the source
h: Planck's const. 6.626×10^{-34} Js
k: Boltzmann's const 1.381×10^{-23} JK^{-1}



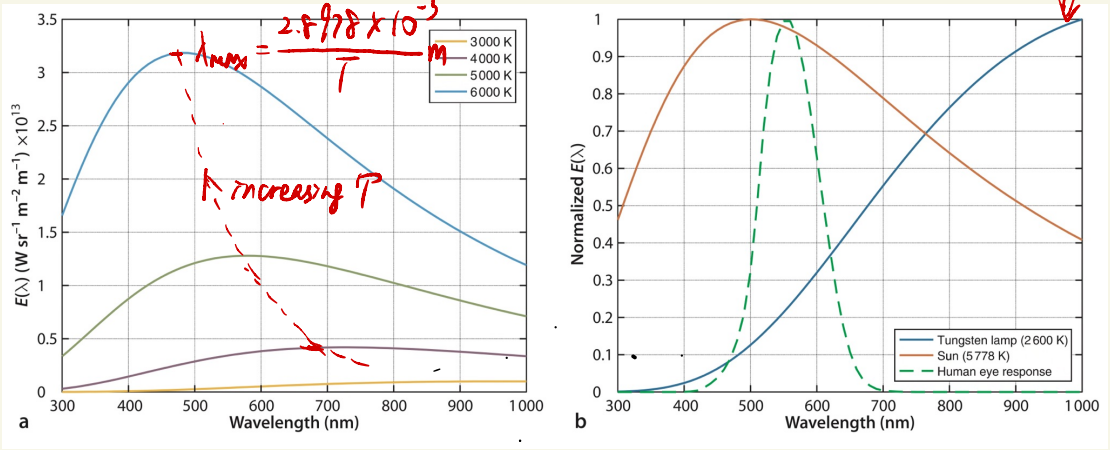
Radiation

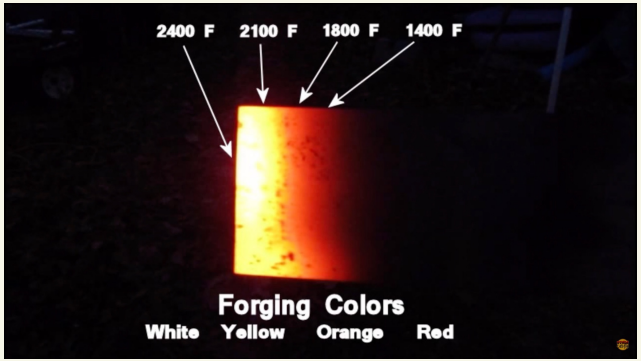
$E(\lambda)$ — e.g. from a hot body — blackbody radiation — Planck's law

$$\frac{2hc^2}{\lambda^5\left(e^{\frac{hc}{\lambda kT}}-1\right)}$$

tungsten lamp $E(\lambda)$ (scaled by 56 for readability)

most power falls in infrared band which we perceive as heat not light

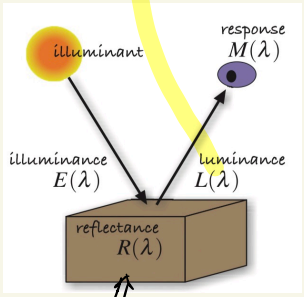




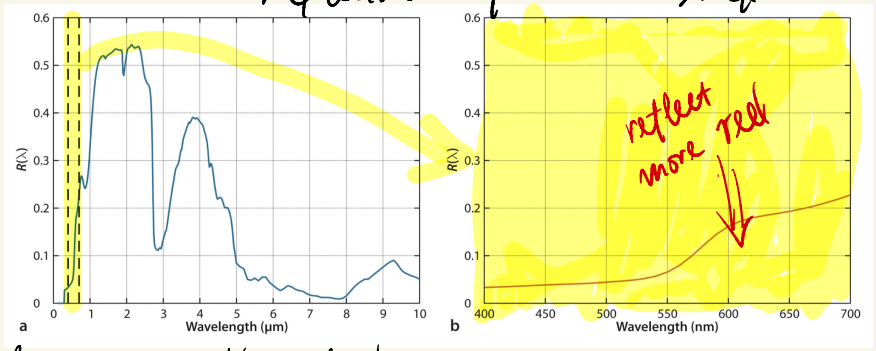
object starts to glow red at around 800K & moves to orange, yellow, toward white

Absorption & Reflectance

$L(\lambda) = E(\lambda) R(\lambda)$ $W m^{-2}$

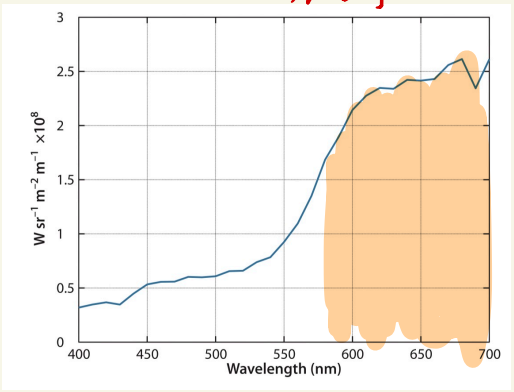


Reflectance of a red brick



illuminance of sun.

$L(\lambda) = E(\lambda) R(\lambda)$



types
- specular (as from a mirror-like surface)
- lambertian : diffuse reflection as from a matte surface

Color

* the concept of cold & warm colors

Same density

* humans perceive different wavelengths differently: