Computer Vision
in
Health Care applications

Agenda

- CV researches
- CV device
- Available direction
- Technologies combination

Motivation – Why HC?

Generally:

- Each person sick
- No one wants to be sick
- Any one want prevent illness
- Any one want to be ill less

Basic illness stages:

1) Feel bad
2) Define disease and prompt treatment
3) Get treatment and wait
4) If still feel bad goto 2

Today focuses:

Part I: Define disease

Part II: Prompt treatment

Part I

What we need to define disease?

-> Observation of medical parameters
(once or over time)

- Problems?

-> Need doctor, need spend time…

- Solution?

-> Computer application can do the observation

Example 1:

Noncontact Physiological Measurements Using a Webcam

JANUARY 2011

Previous solutions for noncontact measurement of vital signs

- laser Doppler

- Microwave Doppler radar

- Thermal imaging

Common drawback:

Systems are expensive and require specialist hardware.

Newer approach

Simple, **low-cost** method for measuring multiple physiological parameters using a **basic webcam**.

Measurements:

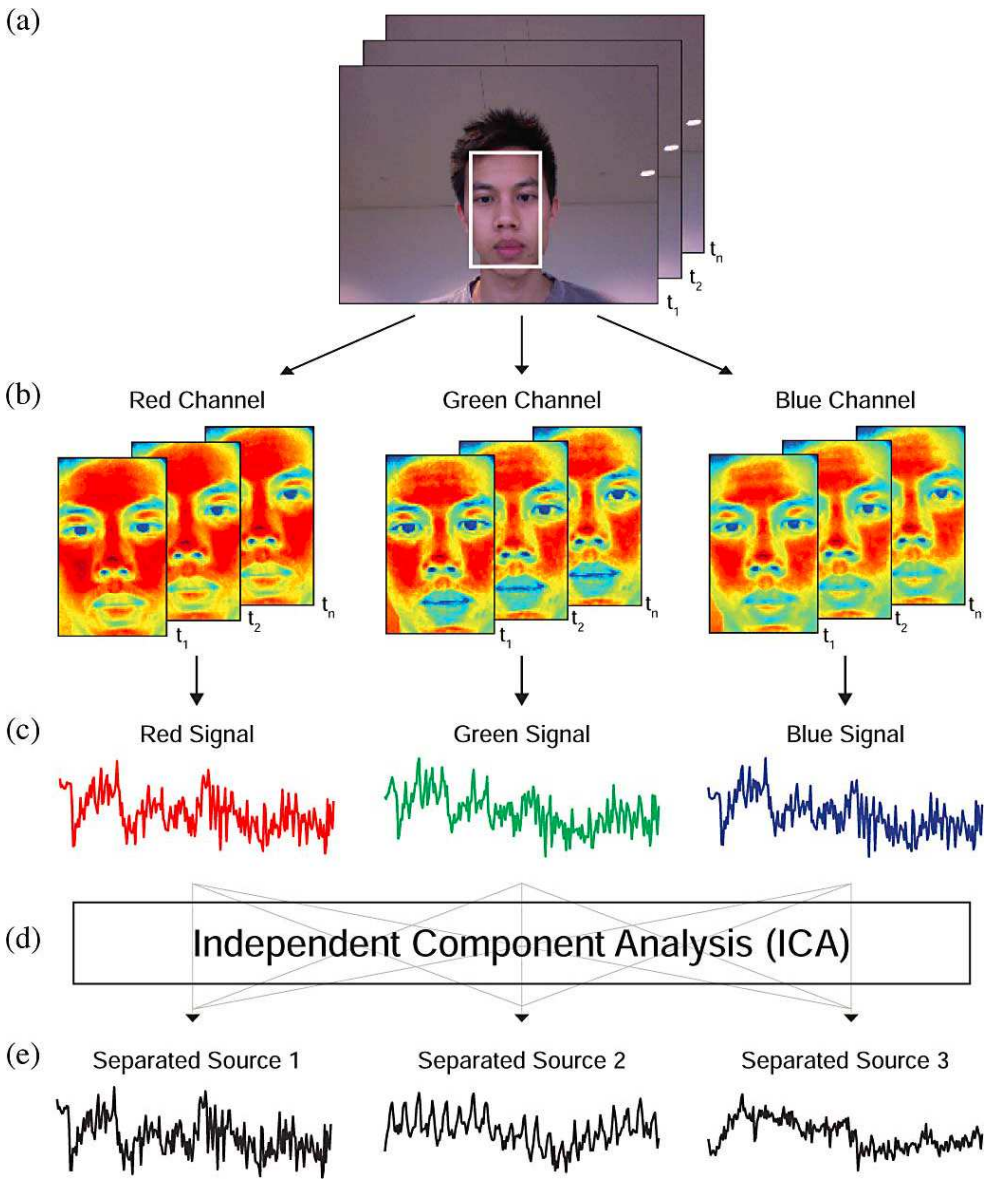
-Blood volume pulse (נפח הדם)

-Heart rate (דופק)

-Respiratory rate (קצב הנשימה)

-HR variability (זמן בין פעימות הלב)

Recovery of the BVP waveform



(a) Automatically select the ROI

(b) ROI is decomposed into **red**, **green**, and **blue** channels each frame

(c) Average over all pixels in the ROI

(d) ICA – separate three independent sources

(e) In this example, the BVP is visible in the **second source** signal.

My evaluation for the paper

- Approach work
- 80 % water
- One example shown
- Interest 45 of 100

What’s next?

Similar, but more impressive, research example

Example 2:

Video Magnification for Revealing Subtle Changes

Year 2012

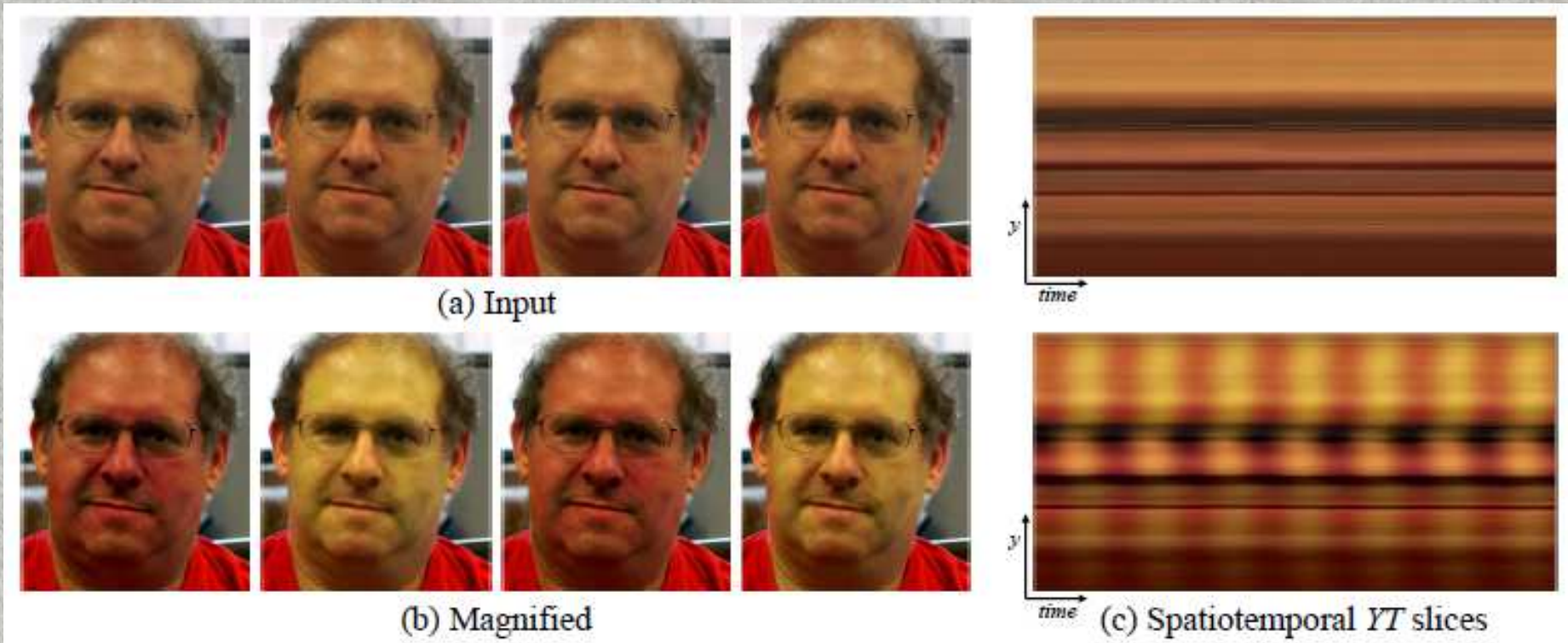
Overview

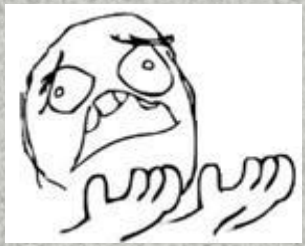
- Video with temporal **variations**
- Variations are **difficult** or **impossible** to see
- Amplify and Display them
- News: motion magnification

Color amplification

- **Time series** of **color values** at any spatial location (pixel)
- **Amplify variation** in a given temporal frequency band of interest.

Color amplification result:



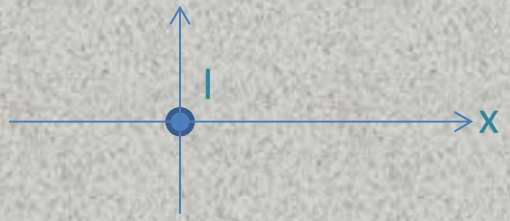


Why picture example? Show video!!

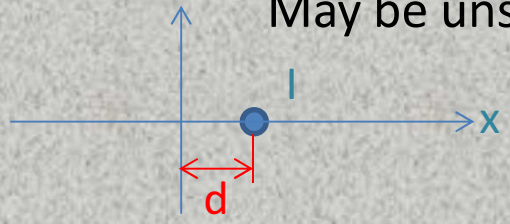
Color Amplification

Motion magnification

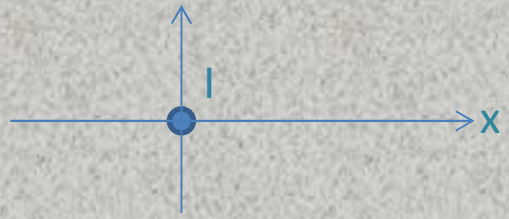
Original video:



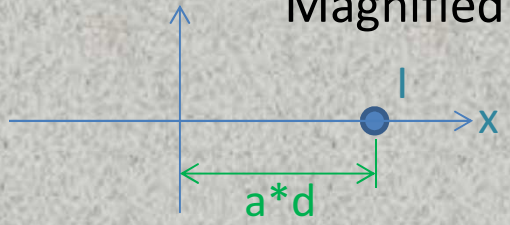
Original motion
May be unseen by eye



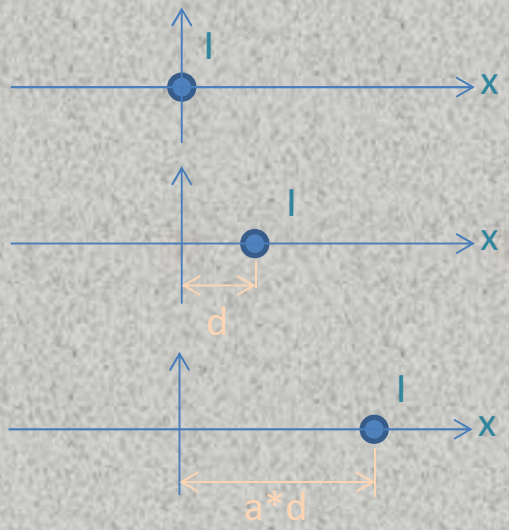
Result video:



Magnified motion



Algorithm overview



Intensity

$I(x,t)$

Assumption (small motion):

$I(x,t) = f(x + d(t))$

We want (amplify the small motion):

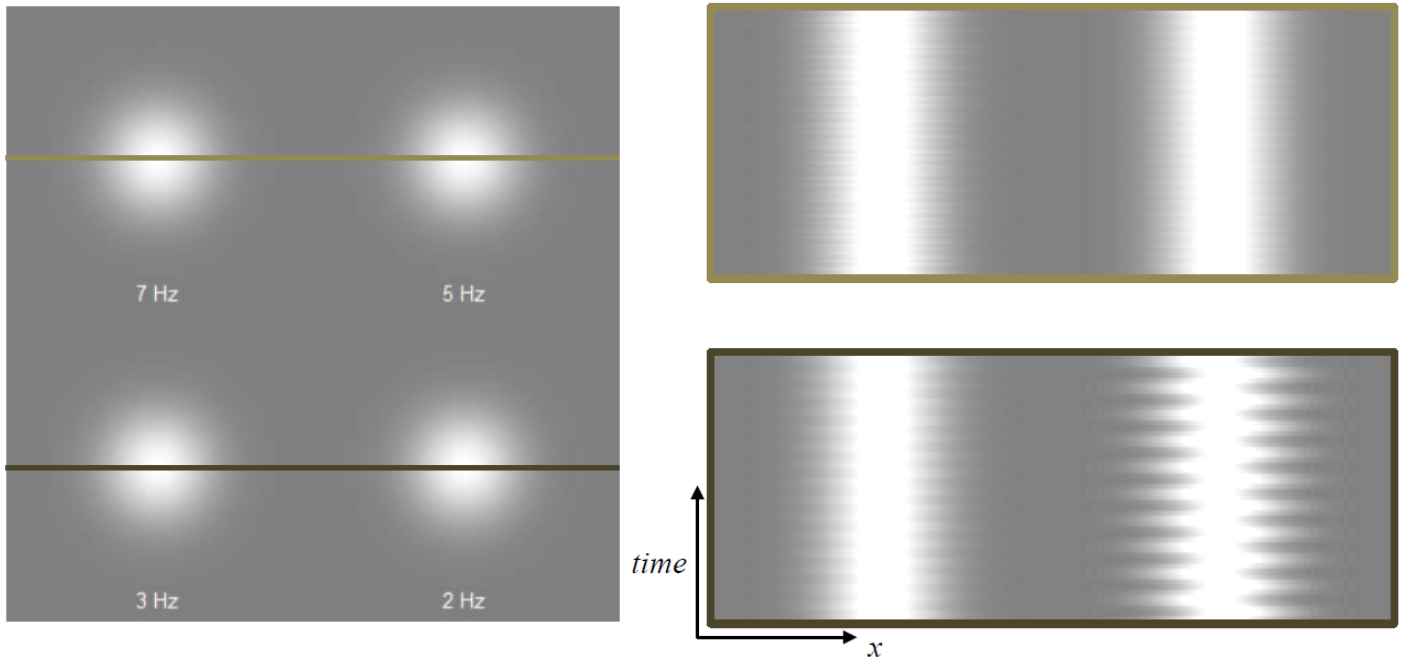
$I(x,t) = f(x + (1+a)d(t))$

First-order Taylor series

$$I(x,t) = f(x + d(t)) \approx f(x) + d(t)\frac{df(x)}{dx}$$

- Apply band pass filter to $I(x; t)$
- The result: $B(x,t) = d(t)\frac{df(x)}{dx}$
- Amplify the $B(x,t)$ and add it to the source signal $I(x; t)$:

$$I_{res}(x,t) = I(x,t) + aB(x,t) \approx f(x) + (1+a)d(t)\frac{df(x)}{dx} \approx f(x + (1+a)d(t))$$



- Each blob oscillating at ***different*** temporal ***frequencies***
- Used ideal temporal bandpass ***filter of 1-3 Hz*** to amplification within the specified passband.
- See amplified motion of the ***2 Hz*** blob or wait to video example

Source

My evaluation for the paper

- Approach work very well
- Not easy, but interesting
- Good examples shown

What's next?

CV* device: Netra

*Computer + Regular Vision

Example 3:

NETRA: Refractive Tests on a Mobile Phone

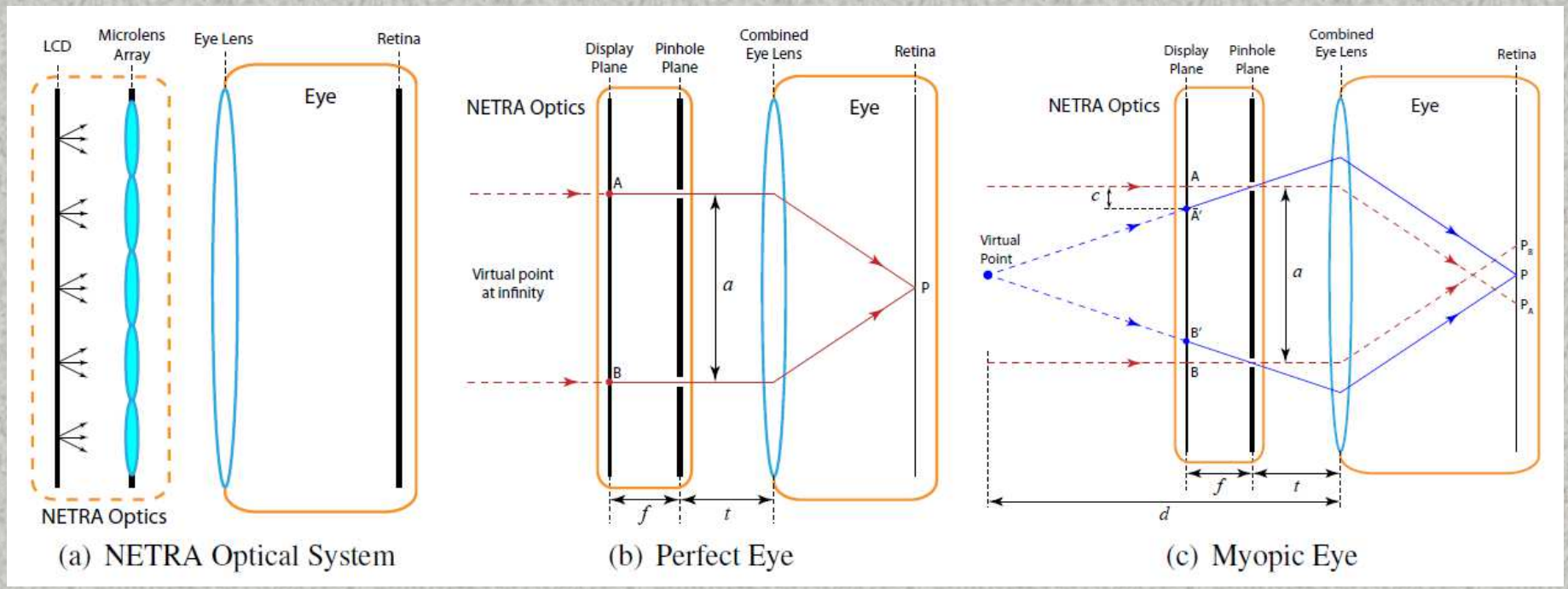
* Year 2010


revolutionary
ideas 2011
TEDx Boston
x = independently organized TED event

Device overview

Portable, **inexpensive** and **interactive** solution for estimating refractive errors in the human eye.

Device usage



Device usage

Problems:

- The solution relies on ***subjective feedback***
- Cannot be used by individuals who **cannot reliably** perform the user-required tasks, such as very young children.

What’s next?

Possible future direction

(How CV can improve existed solution)

Paper:

The Future of Sleep Medicine

* Year 2011

Very critically!

- We sleep **every day**
- Affects **all the functionality** of the human body

Sleeping
(generally)

- *Measures made by **counting events** across the sleep:*
  - Apneas (דום נשימה)
  - Hypopneas (נשימה איטית מהרגיל)
  - Desaturations (per hour of sleep) (נפילת רמת חמצן יותר מ-3%)
  - Arousals (התעוררות)

- These Measures ***used for***:
  - Thresholds above which disease is defined
  - Characterizing disease severity
  - …

- There are many possible uses of CV in this field
- Let’s see *simple* example

Nice application example

Sleep Cycle alarm clock

- The natural way to wake up feeling **rested** and **relaxed**.
- An intelligent alarm clock that analyzes your sleep and wakes you in the **lightest sleep phase**

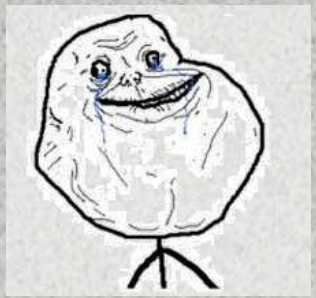
Nice application example

Nice application example

Nice application example

Disadvantages*

- Placement
- “mattress” depending
- “Not FA phenomenon”



* Can be improved by CV technologies

Part II

- We saw several examples of “how we can define disease”
- Now we will see “how treatment can be prompted”

Challenges

- Medical information is doubling every 5 years
- Much of it is unstructured
- 81% of physicians spend <5h/month reading medical material

More challenges

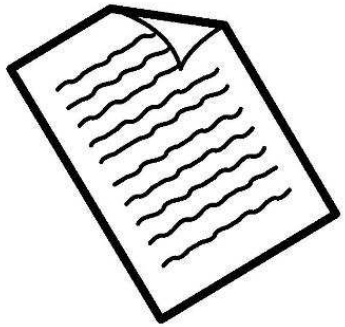
- 1 in 5 diagnosis that are estimated to be inaccurate or incomplete
- 1.5 million errors in medication prescribed (U.S. per year)
- 44000-98000 Americans die each year from preventable medical errors

How the CV can help?

- The patient, for example, takes picture of his skin disease.

- Send the picture thru the internet to server

- Server response with answer:
  - **what is the disease**
  - **what to do to treat it**.



But how the server knows?

Ideas?

- Doctor receives the pictures and send the answer back.

  Problems:

  Again doctor? Response time? 24/7/365?

- Use the computer

Watson

Support medical professionals

when they make decisions

- Watson uses:
  - natural language capabilities
  - hypothesis generation
  - evidence-based learning

Jeopardy! game

- ***Jeopardy!*** is an American television quiz show


Jeopardy! video
(05:14.5 -- 06:17)
THINK

In my opinion it’s impressive

Summary

- Simple Physiological Measurements
- Video Magnification
- See in to eye
- Future of sleeping
- Watson

Thanks