COSFIRE Filters in Object Recognition

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Motivation

Lifestyle Hazards

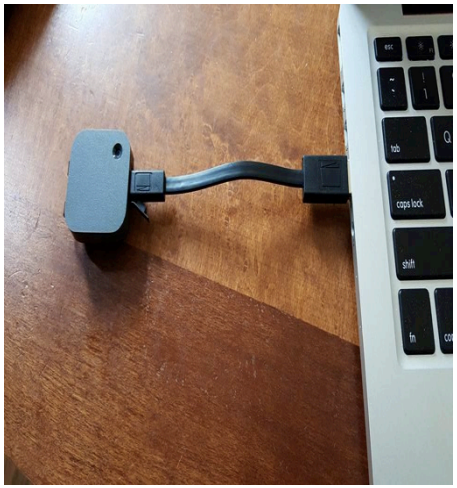
Why Life Logging

First : WearCam by Steven Mann.

Later: SensCam, Narrative Clip ….

Narrative Clip Camera

Camera Specifications



- Lightweight, 20gm
- Dimension, 36x36x9mm
- Camera Sensor resolution, 5MP
- Frequency, an image/30sec
- Memory, 8GB

Camera

Algorithm

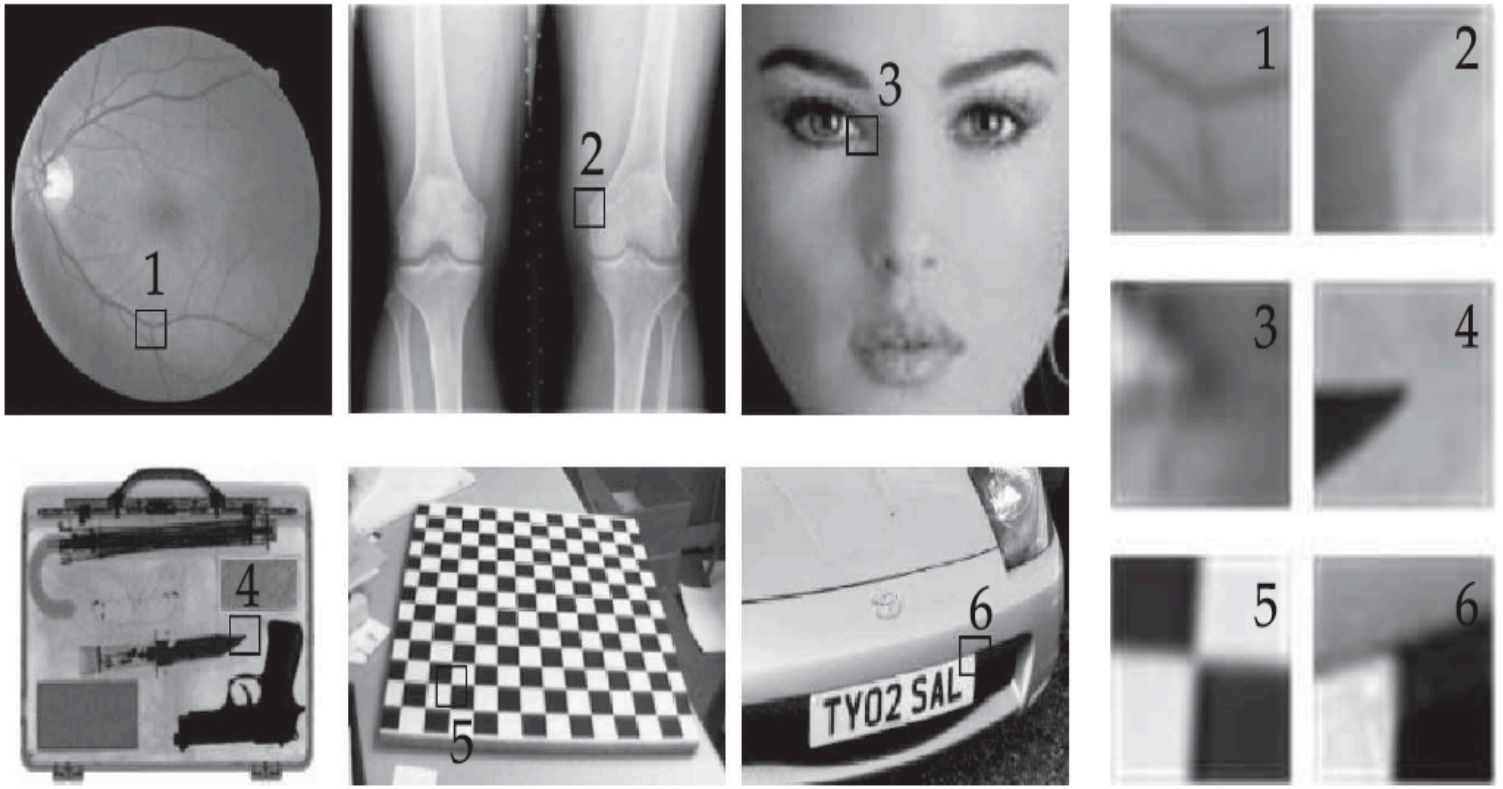
Trainable COSFIRE Filters

COSFIRE: Combination Of Shifted Filter REsponses

Mr. George Azzopardi

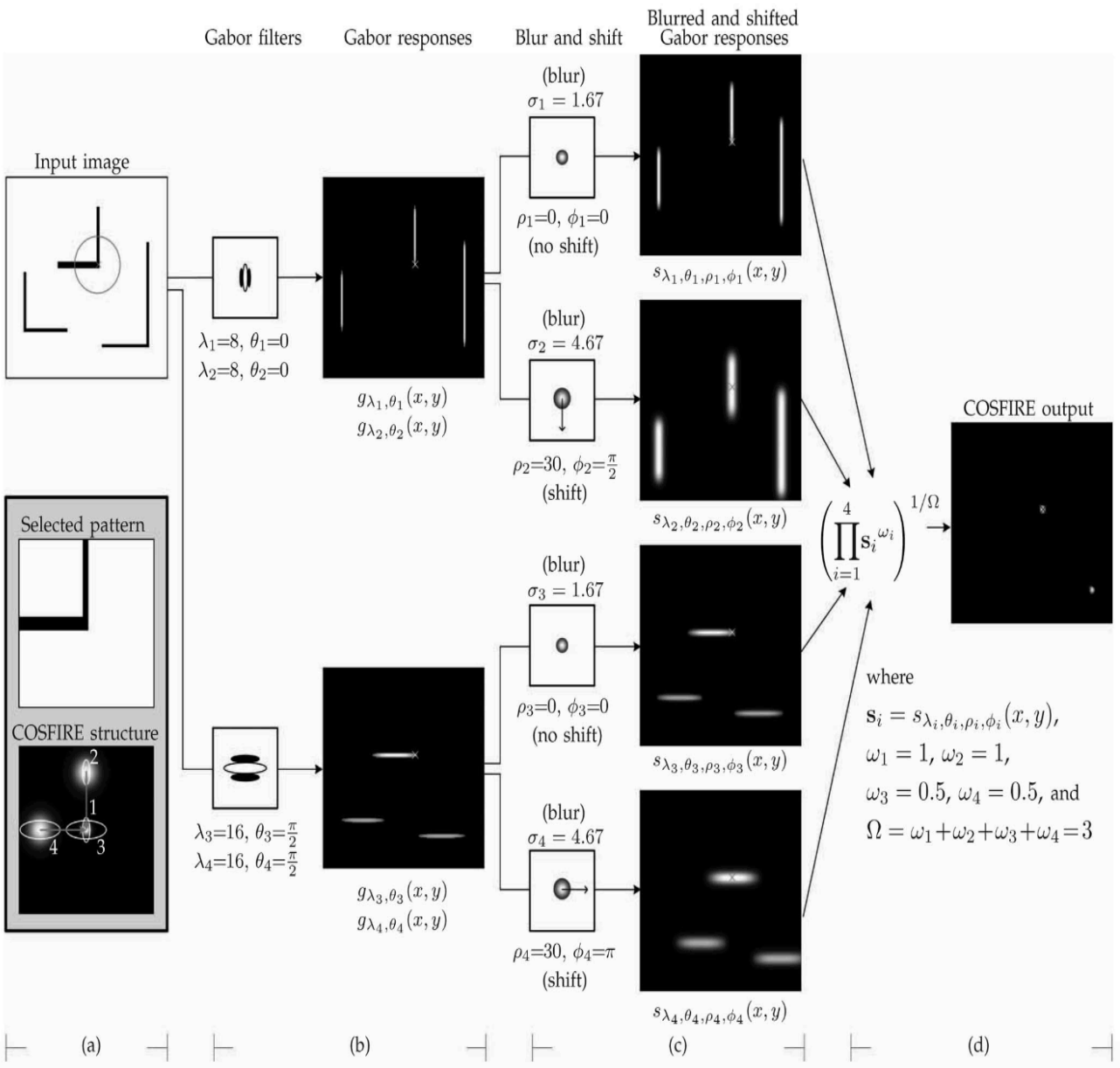
Professor Nicolai Petkov

Keypoints & Prototype



(a) (b)

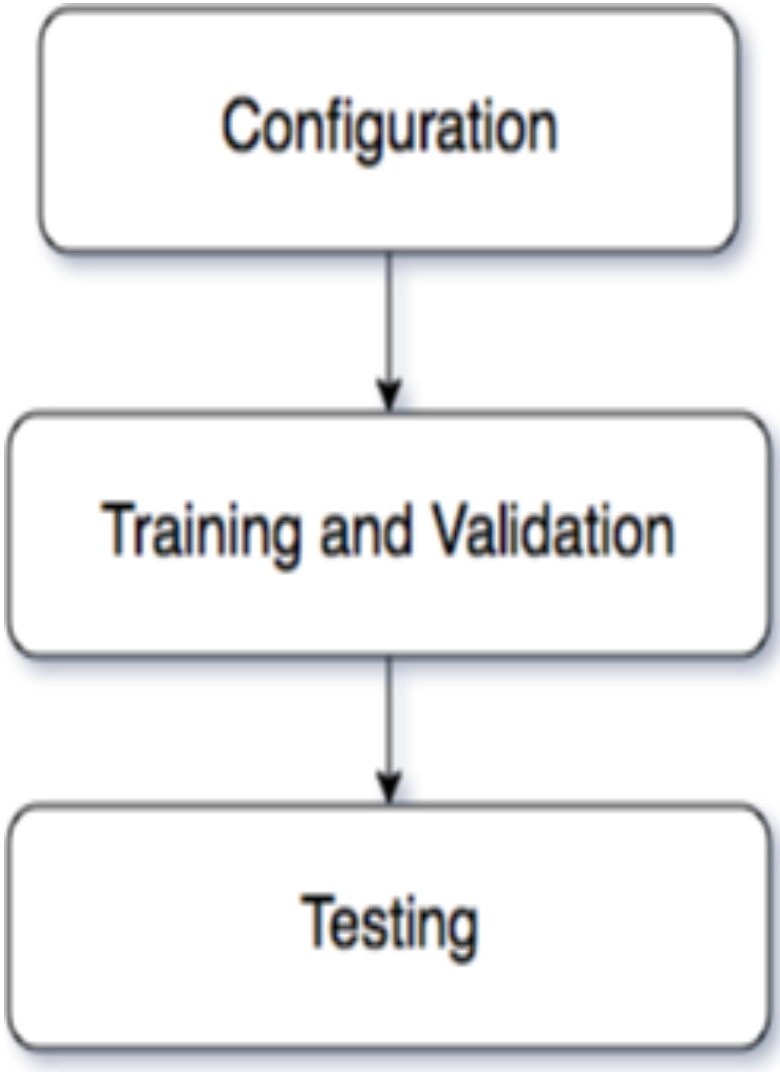
Algorithm


Gabor filters
Gabor responses
Blur and shift
Blurred and shifted Gabor responses
Input image
(blur)
$\sigma_1 = 1.67$
ρ_1=0, ϕ_1=0
(no shift)
$s_{\lambda_1,\theta_1,\rho_1,\phi_1}(x,y)$
λ_1=8, θ_1=0
λ_2=8, θ_2=0
$g_{\lambda_1,\theta_1}(x,y)$
$g_{\lambda_2,\theta_2}(x,y)$
(blur)
$\sigma_2 = 4.67$
ρ_2=30, $\phi_2=\frac{\pi}{2}$
(shift)
$s_{\lambda_2,\theta_2,\rho_2,\phi_2}(x,y)$
COSFIRE output
Selected pattern
COSFIRE structure
(blur)
$\sigma_3 = 1.67$
ρ_3=0, ϕ_3=0
(no shift)
$s_{\lambda_3,\theta_3,\rho_3,\phi_3}(x,y)$
λ_3=16, $\theta_3=\frac{\pi}{2}$
λ_4=16, $\theta_4=\frac{\pi}{2}$
$g_{\lambda_3,\theta_3}(x,y)$
$g_{\lambda_4,\theta_4}(x,y)$
(blur)
$\sigma_4 = 4.67$
ρ_4=30, $\phi_4=\pi$
(shift)
$s_{\lambda_4,\theta_4,\rho_4,\phi_4}(x,y)$
$\left(\prod_{i=1}^{4} \mathbf{s}_i{}^{\omega_i}\right)^{1/\Omega}$
where
$\mathbf{s}_i = s_{\lambda_i,\theta_i,\rho_i,\phi_i}(x,y)$,
$\omega_1 = 1$, $\omega_2 = 1$,
$\omega_3 = 0.5$, $\omega_4 = 0.5$, and
$\Omega = \omega_1+\omega_2+\omega_3+\omega_4 = 3$
(a)
(b)
(c)
(d)

My Experiments

Recognising Laptops

Method



Prototype

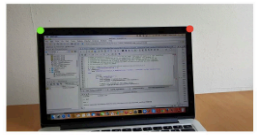
Laptop

Keypoints in a laptop

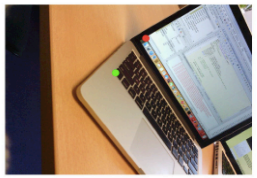
(a) Lap01

(b) Lap02

(c) Lap03



(d) Lap04



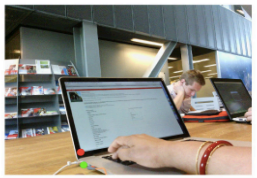
(e) Lap05

(f) Lap06

(g) Lap07

(h) Lap08

(i) Lap09



(j) Lap10

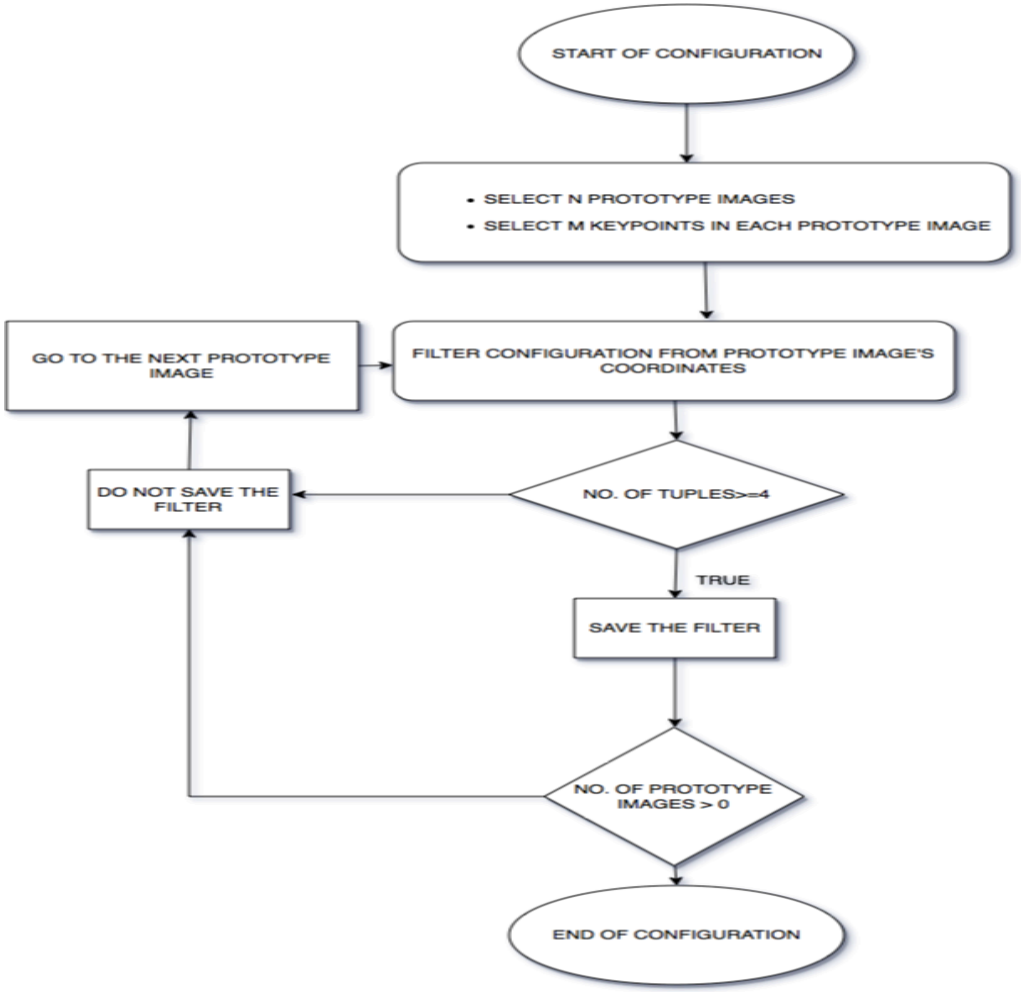
Resizing & Preprocessing

Image has a resolution of 5MP !!

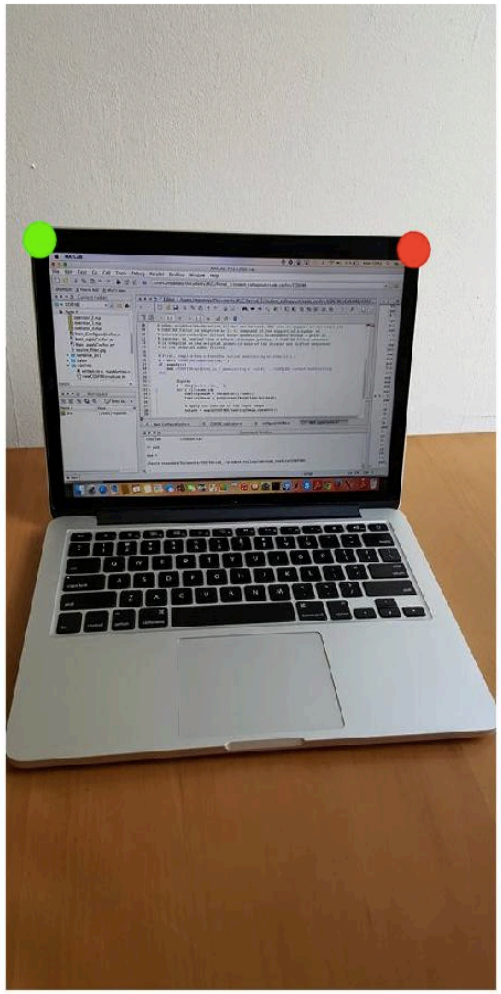
Resizing is important.

Preprocessing is converting the coloured images into grey scale

Configuration

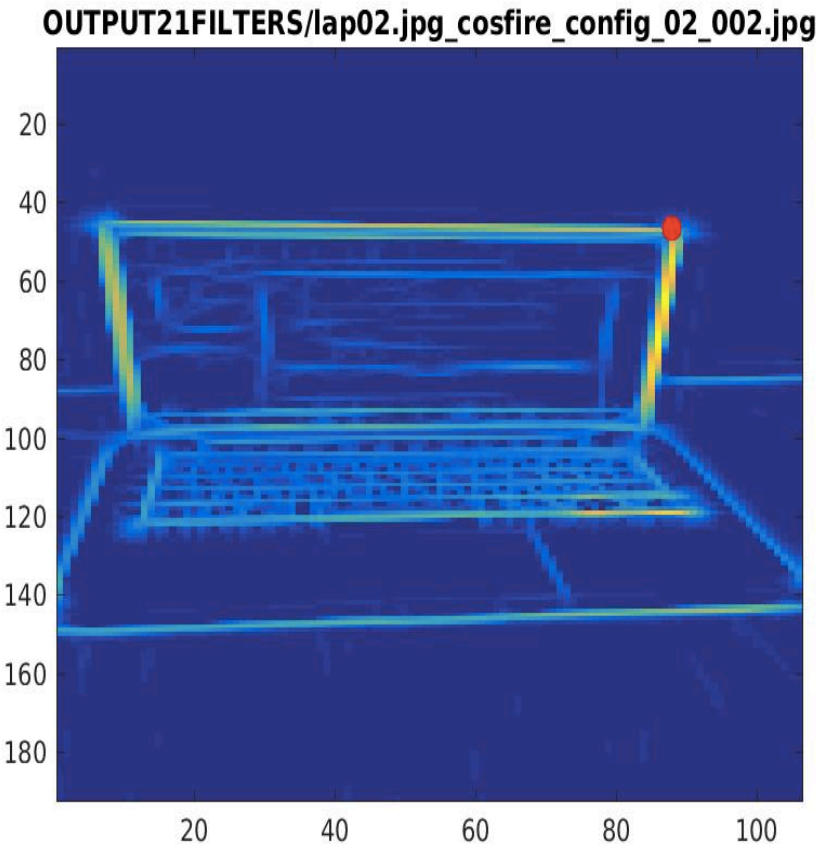


Choosing a key point



The two selected keypoints

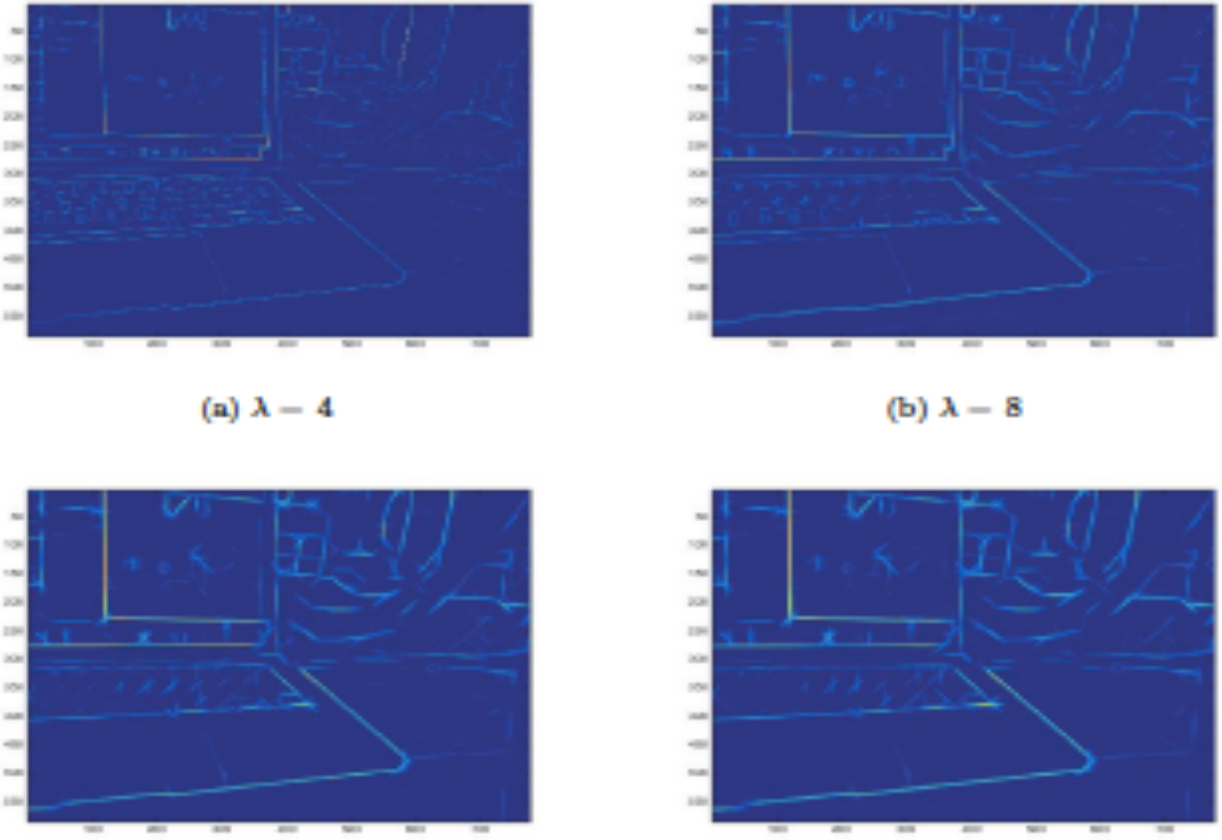
Prominent Edges in the prototype



Gabor Parameters

1. Wavelength
2. Aspect Ratio
3. Bandwidth
4. Inhibition Angle
5. Inhibition Method

Effect of Wavelength

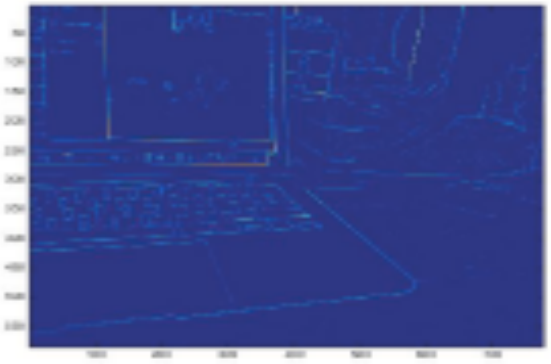


(a) $\lambda - 4$ (b) $\lambda - 8$

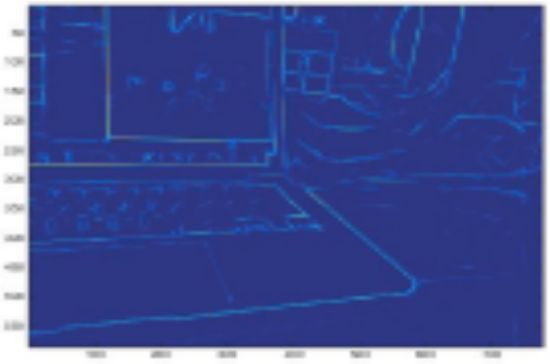
(c) $\lambda - 12$ (d) $\lambda - 14$

Figure 3.2: The effect of variation in λ values

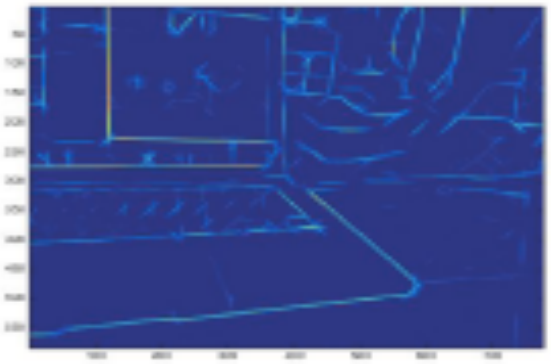
Effect of Bandwidth



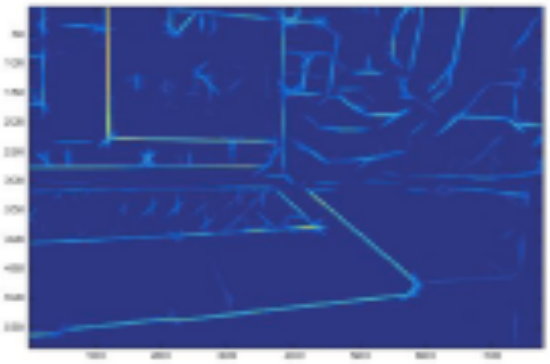
(a) $\lambda - 4$



(b) $\lambda - 8$



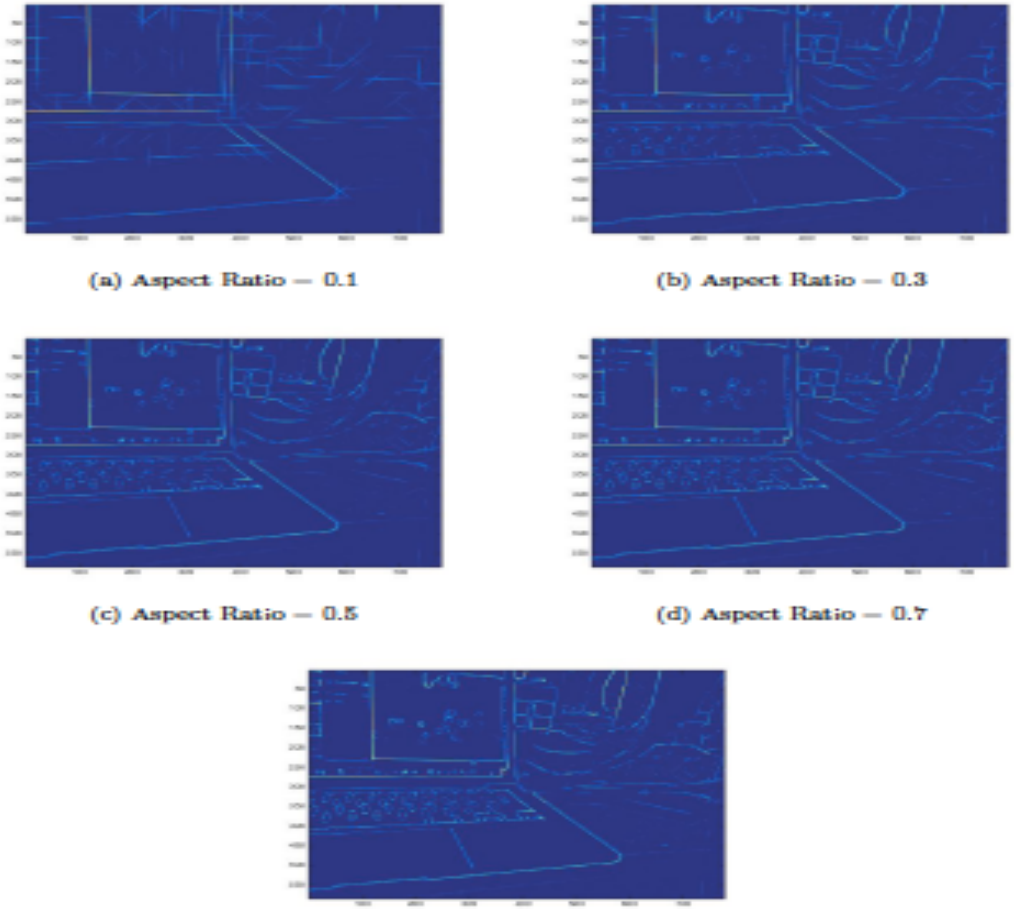
(c) $\lambda - 12$



(d) $\lambda - 14$

Figure 3.2: The effect of variation in λ values

Effect of Apect Ratio



(a) Aspect Ratio — 0.1

(b) Aspect Ratio — 0.3

(c) Aspect Ratio — 0.5

(d) Aspect Ratio — 0.7

(e) Aspect Ratio — 1

Figure 3.3: The effect of variation in Aspect Ratio values

Effect of Inhibition Angle

(a) Inhibition with angle 0.02

(b) Inhibition with angle 0.03

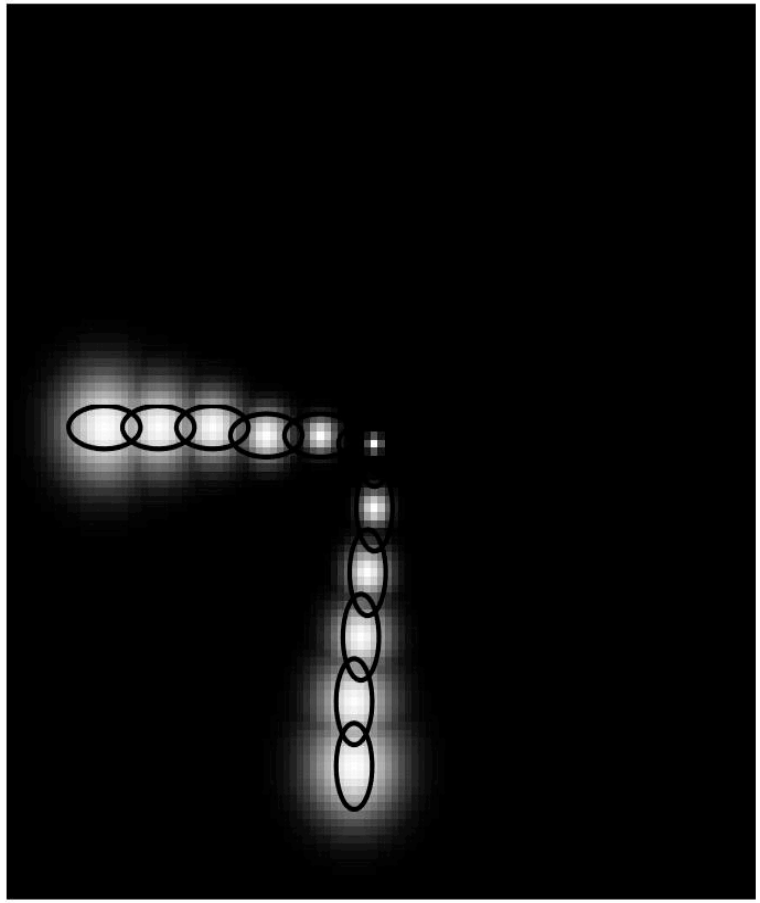
Effect of Inhibition Method

Final Gabor Parameter Values

1. Wavelength = 8
2. Aspect Ratio =0.3
3. Bandwidth = 2
4. Inhibition Angle = 0.04
5. Inhibition Method =
   anisotropic = 2

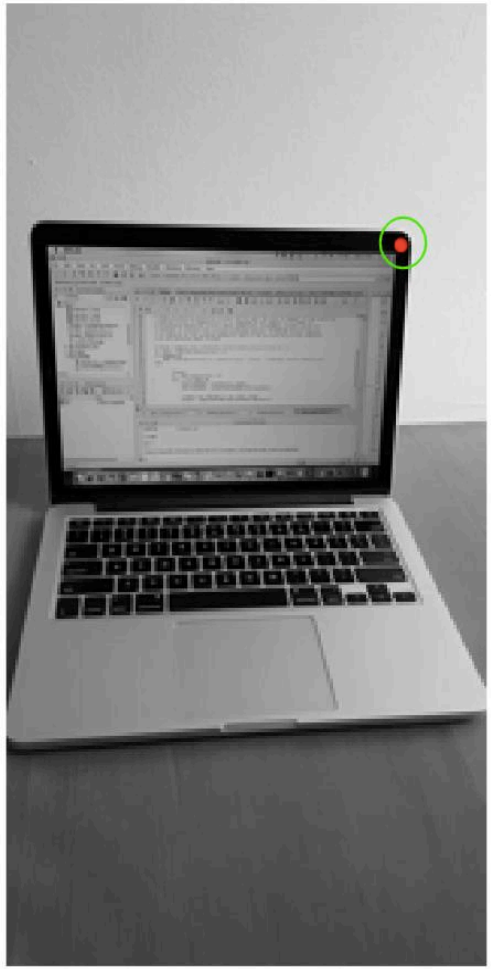
Tuples

lap02.jpg_cosfire_filter_02_001.jpg



Object Recognition

applied_marked02001.jpg



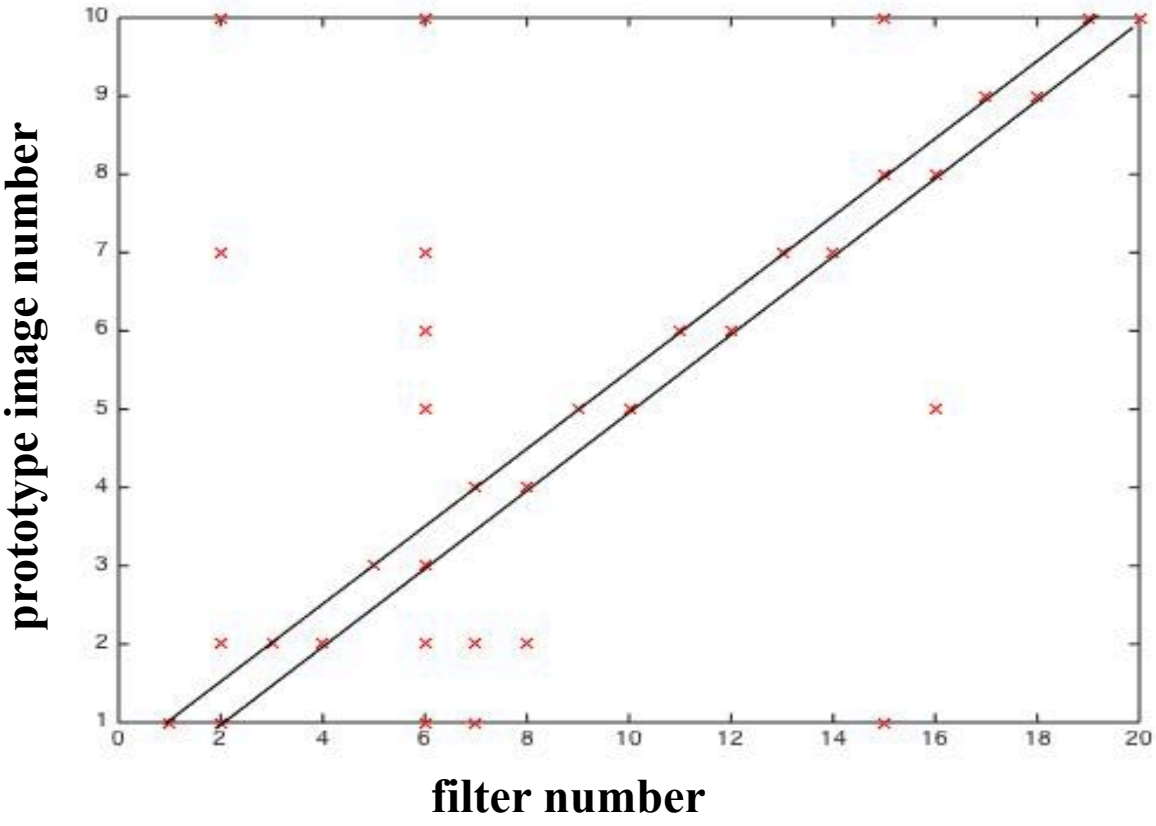
True Positive

applied_marked01001.jpg

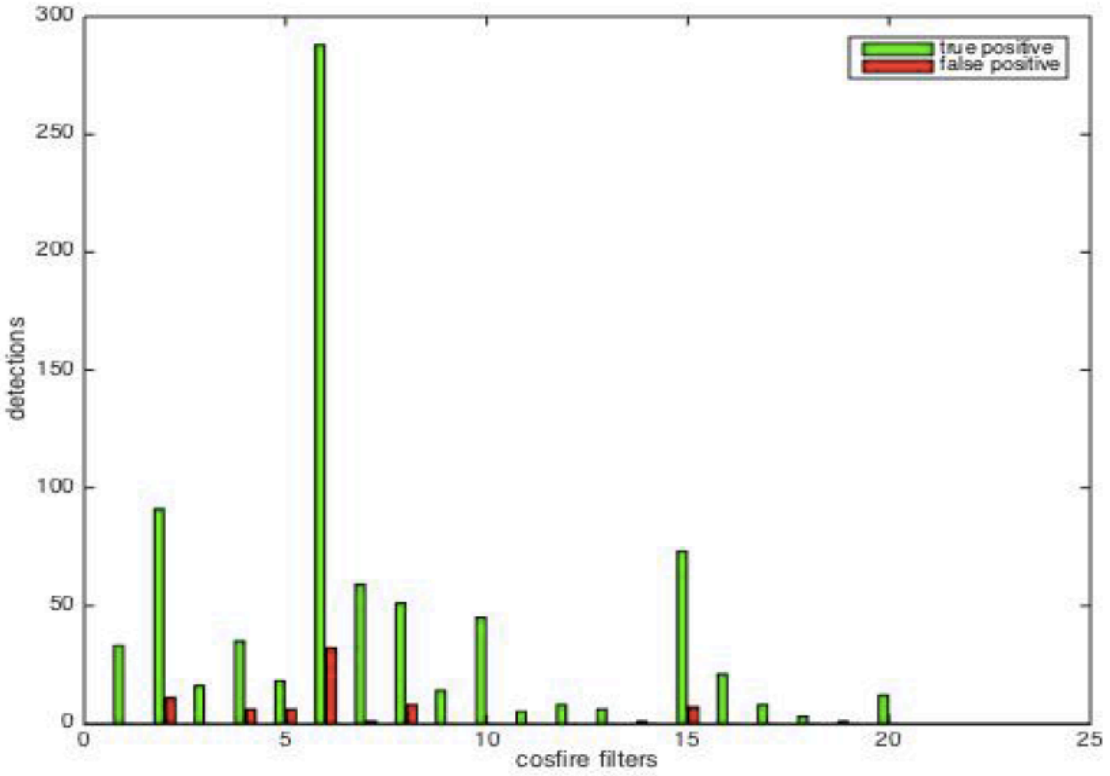
False Positive

applied_marked_095710.jpg_1_1_2.mat

Training & Validation



TP and FP on Test Images



COSFIRE filter	TP	FP
cf01	33	0
cf02	91	11
cf03	16	0
cf04	35	0
cf05	18	6
cf06	288	32
cf07	59	1
cf08	51	8
cf09	14	0
cf10	45	0
cf11	5	0
cf12	8	0
cf13	6	0
cf14	1	0
cf15	73	7
cf16	21	0
cf17	8	0
cf18	3	0
cf19	1	0
cf20	12	0

Testing Summary

Total Images	410
TP	248
FP	51
TN	85
FN	26
Precision	0.83
Recall	0.905
F1-Measure	0.866

Total Images	410
TP	148
FP	1
TN	135
FN	126
Precision	0.993
Recall	0.54
F1-Measure	0.7

Troublesome Images

applied_filno_3_4_4_14_2_102941.jpg.mat

Troublesome Images

applied_test_120030.jpg_filterno_7_144_15_3.mat

Troublesome Images

applied_filno_5_2_2_13_3_135321.jpg.mat

Computing Resources - Laptop

Model Name	Mac Book Pro
Operating System	Yosemite
Processor	Intel Core (TM) i7 4558U @2.80GHz
Number of Processors	1
Total Number of Physical Cores	2
Memory	16GB
Graphics	Intel Iris 1536 MB

Key compute steps

- Dataset size – 410 images; operators/filters – 20.

① Filter configuration
②Operator/Filter application
③Image data base and access
④Result data base (incl. plots)

- Steps 1,3, and 4 takes <10% of total compute time. So Step 2 needs to be sped up.
- Single application of a filter (single image) takes ~ 210s.
- Application time on the entire data set ~ 24days !!!
  - Reduce the compute time for a applycosfire
  - Utilize the multicore architecture
  - Big compute servers

Compute speed up

- **Reduction of compute time for apply cosfire**

Scale Factor	0.2	0.3	0.5	0.6	0.8	1.0
Time Taken(sec)	10.4	20.7	50.7	72.8	132.6	210.5

compute time for a single filter application on an image (using one physical core for difference resize/scale factors.

- **Compute time is not linear wrt to scale factor**
- **We chose a scale/resize factor of 0.3. A speed up of ~10.**
- **Utilization of multicore Architecture**
- **We used the parfor construction in matlab to process the images in parallel. Code estimates optimal number of workers.**
- **Bigger Server compute machines**
- **We used facilities as Kapteyn Astronomical Institute.**
- **Possible application for galaxy classification/object detection.**

Bigger Server Machines

Processor type	Time taken (single physical core)	No. of physical cores (one node)
Intel(R) Xeon(R) CPU E7- 8850 @ 2.00GHz	42.00s	80 (hathor)
Intel(R) Xeon(R) CPU E7-8850 v2 @ 2.30GHz	37.10s	96 (argo)
Intel(R) Xeon(R) CPU E5-2630 v3 @ 2.40GHz	20.76s	16 (gaia)
Intel(R) core(TM) i7-4558U CPU @ 2.80 GHz	20.70s	2 (laptop*)
Intel(R) Xeon(R) CPU E5-2670 v3 @ 2.30GHz	20.02s	24 (dawn cluster)
Intel(R) Xeon(R) CPU E5-2698 v3 @ 2.30GHz	19.79s	32 (norma4)
Intel(R) Core(TM) i7-3770S CPU @ 3.10GHz	18.26s	4 (horrocks)

Comparison of average compute time for a single cosfire application on an rescaled image (0.3) using a single physical compute core.

- **Intel Version 3 processors (haswell architecure) are in general faster compared to older versions.**
- **Norma4 was chosen for our work, it has fast cpu, large number of cores, physical memory of 768GB and HDD of 7TB.**

Norma4 Specifications

Compute node name	norma4 (in kapteyn Institute, RuG)
Operating System	Scientific Linux release 7.2 (Nitrogen)
CPUs available	2 x Intel(R) Xeon(R) CPU E5-2698 v3 @ 2.30GHz;
Number of cores	32 (2x16)
Main Memory	768GB
Hard Disk Drive	7.1TB

Multicore Efficiency

No. of Images: 410
Scale factor: 0.3
No. of Filters: 20
No. of applications: 8200
No. of cores used: 29
Starting time: Mon 11 Jul 11:11:54 CEST 2016
Ending time : Mon 11 Jul 13:25:27 CEST 2016
Total time taken: 8013 seconds.

Avg time for single COSFIRE application: $8033/8200 = 0.98$s (Multicore mode)

- **Avg time for single COSFIRE application: 19.79s (single core mode)**
- **Multicore speed up – 19.79/0.98 = 20.25**
- **Multicore efficiency –(20.25/29)*100 = 70%**

Conclusions & Future Works

- Configuration – Choice of parameter and key features
- Successful Object Recognition – precision - 80.3%
  - recall rate - 90.5%
- Optimal Number of Filters
- Computational Speedup – rescaling and multicore.
- Multicore efficiency – 70%.
- Hyper-threading does not improve performance.
- Intel V3 (Haswell architecture) processors are faster than V2 and older processors.
- Bigger Datasets could be considered for robust performance evaluation and improvement.
- Possible application for galaxy classification/object detection.


Thank
you

References

1. George Azzopardi and Nicolai Petkov. Trainable cosfire filters for keypoint detection and pattern recognition. Pattern Analysis and Machine Intelligence, IEEE Transactions on ,35(2): 490–503, 2013.
2. Til Aach, André Kaup, and Rudolf Mester. On texture analysis: Local energy transforms versus quadrature filters. Signal processing , 45(2):173–181, 1995.
3. Roya Kelishadi, Siamak Alikhani, Alireza Delavari, Farshid Alaedini, Afshin Safaie, and Eliyeh Hojatzadeh. Obesity and associated lifestyle behaviours in iran: findings from the first national non-communicable disease risk factor surveillance survey. Public health nutrition , 11(03):246–251, 2008.
4. Katrin Wolf, Albrecht Schmidt, Agon Bexheti, and Marc Langheinrich. Lifelogging: You're wearing a camera? IEEE Pervasive Computing , 13(3):8–12, 2014.
5. http://getnarrative.com/narrative-clip-1
6. **All images apart from my report are either from the research paper[1] or from the google images.**