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Through connectivity in applied computer systems – ADMOS and MARWIN projects

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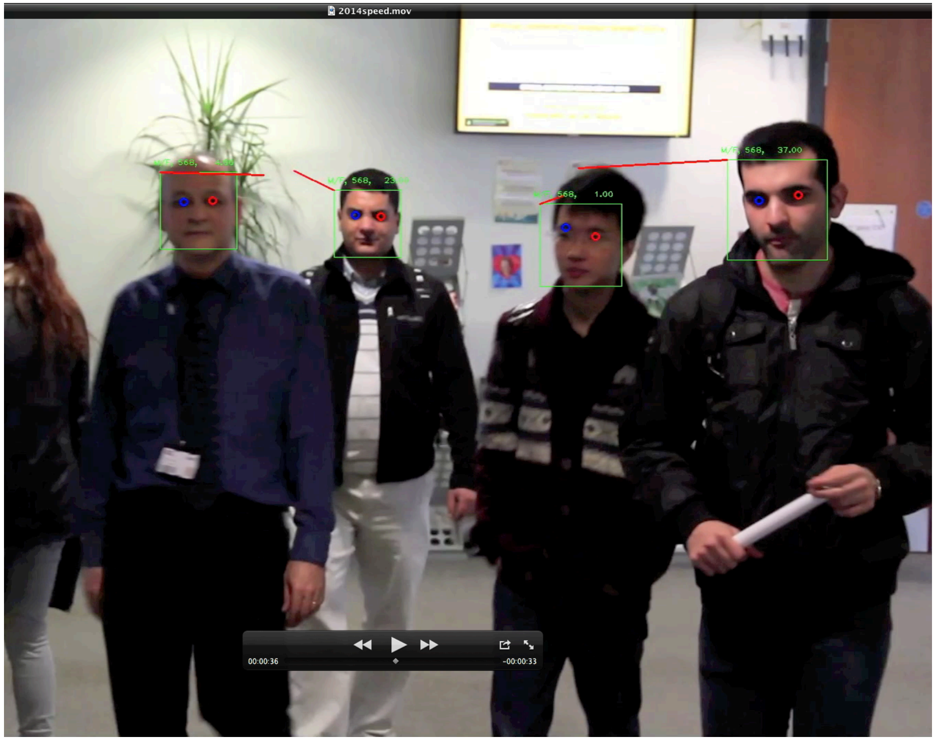
Through Connectivity in Applied Computer Systems – ADMOS and MARWIN Projects

Marcos Rodrigues



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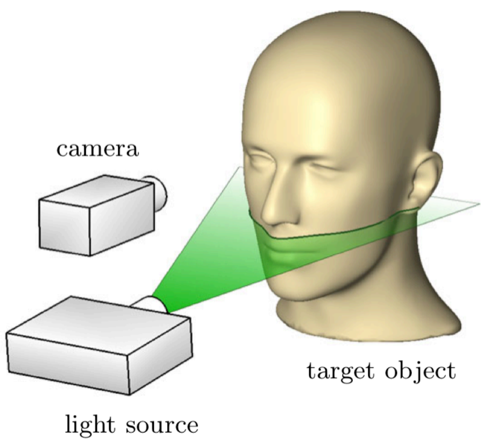
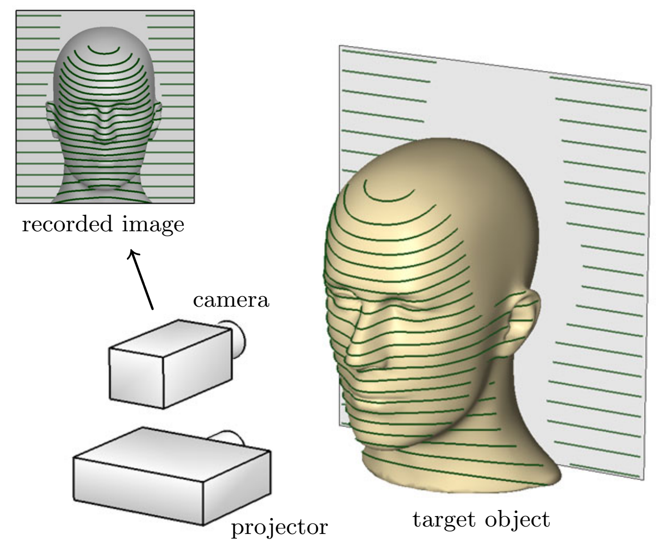
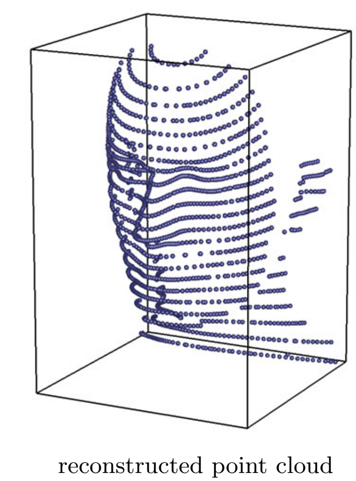
The GMPR 3D scanning technologies

3D with single image







Each light plane is uniquely detected by original algorithms

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The MARWIN Project

FP7 Research for the Benefit of SMEs

Grant Agreement No. 286284, 2011--2014

Project Coordinator:

TWI

Project Members:

Nemetschek BULGARIA

ROLAN ROBOTICS

G-ROBOTS

RECAMLÀSER

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MFKK

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MARWIN: SHU work on various tasks

Marcos Rodrigues, Mariza Kormann

3D Scanner Development
Registration and fusion of 3D models
Translating 3D welding sequence from CAD to scanned model
Dissemination

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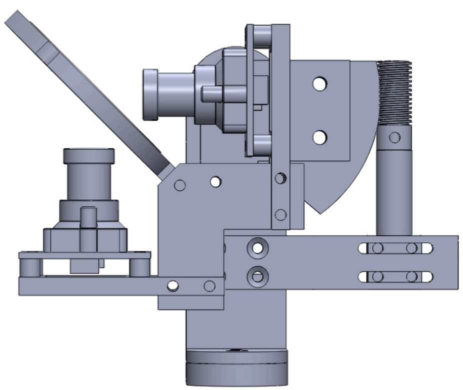
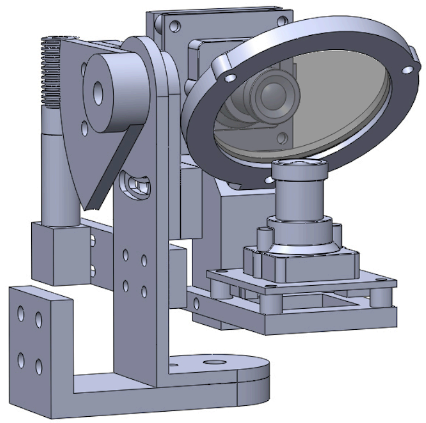
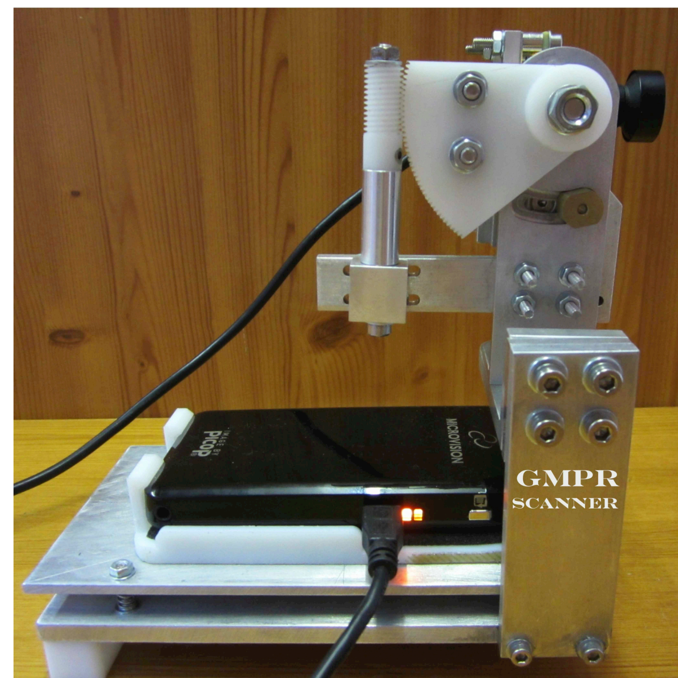
GMPR scanner design

A beam splitter allows for visible and near-infrared cameras to be fitted







The prototype shown uses a MicroVision PicoP laser projector and an IDS CMOS camera (1280x1024)

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Full design integrated into a robotic arm

The actual robotic cell

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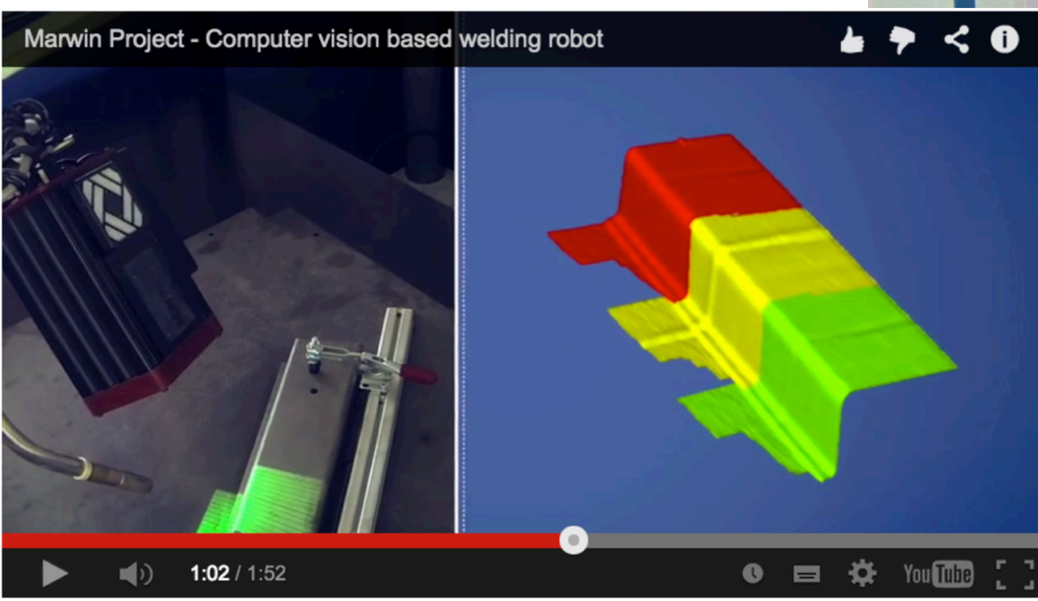
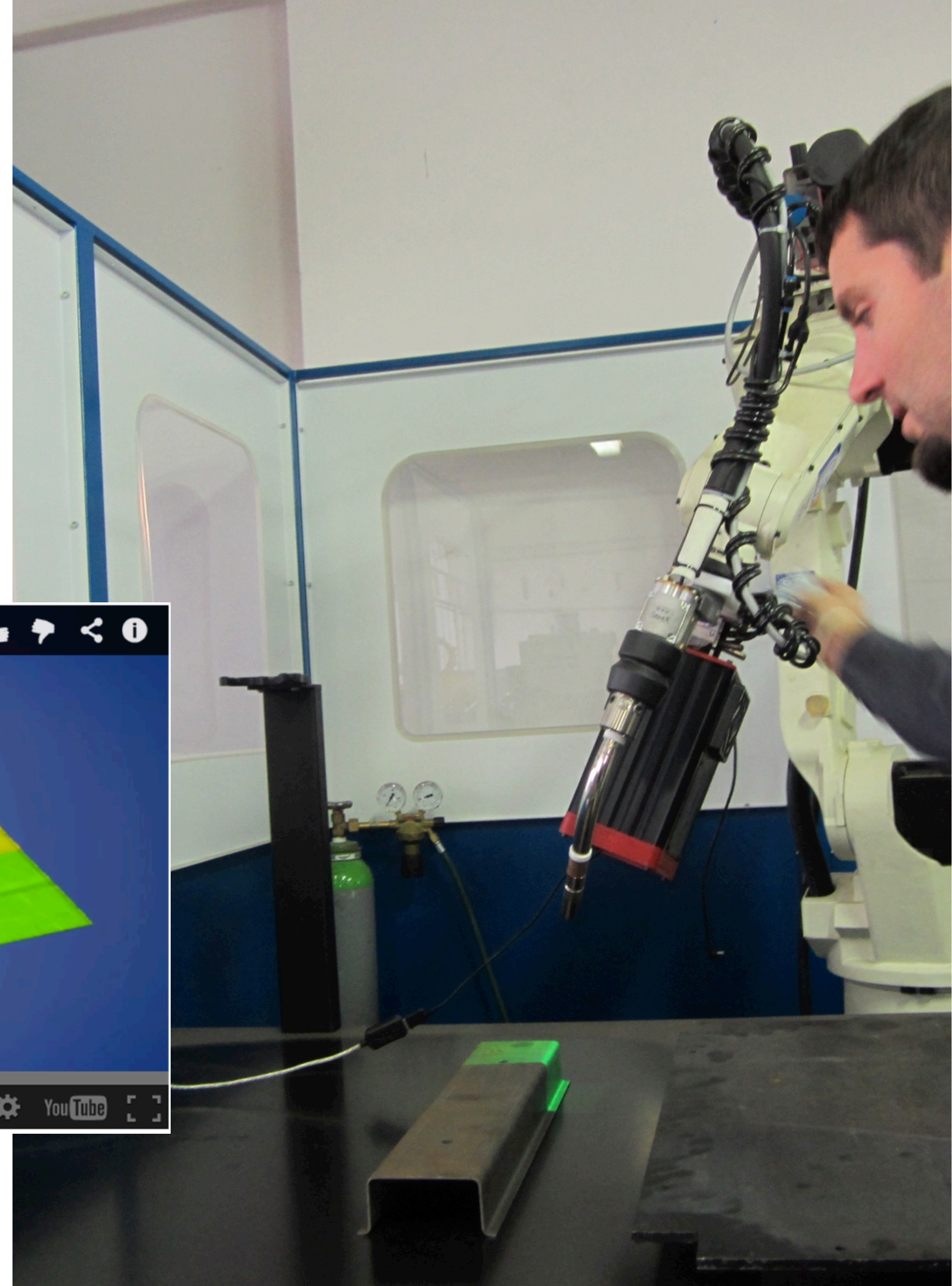
Scanning a part





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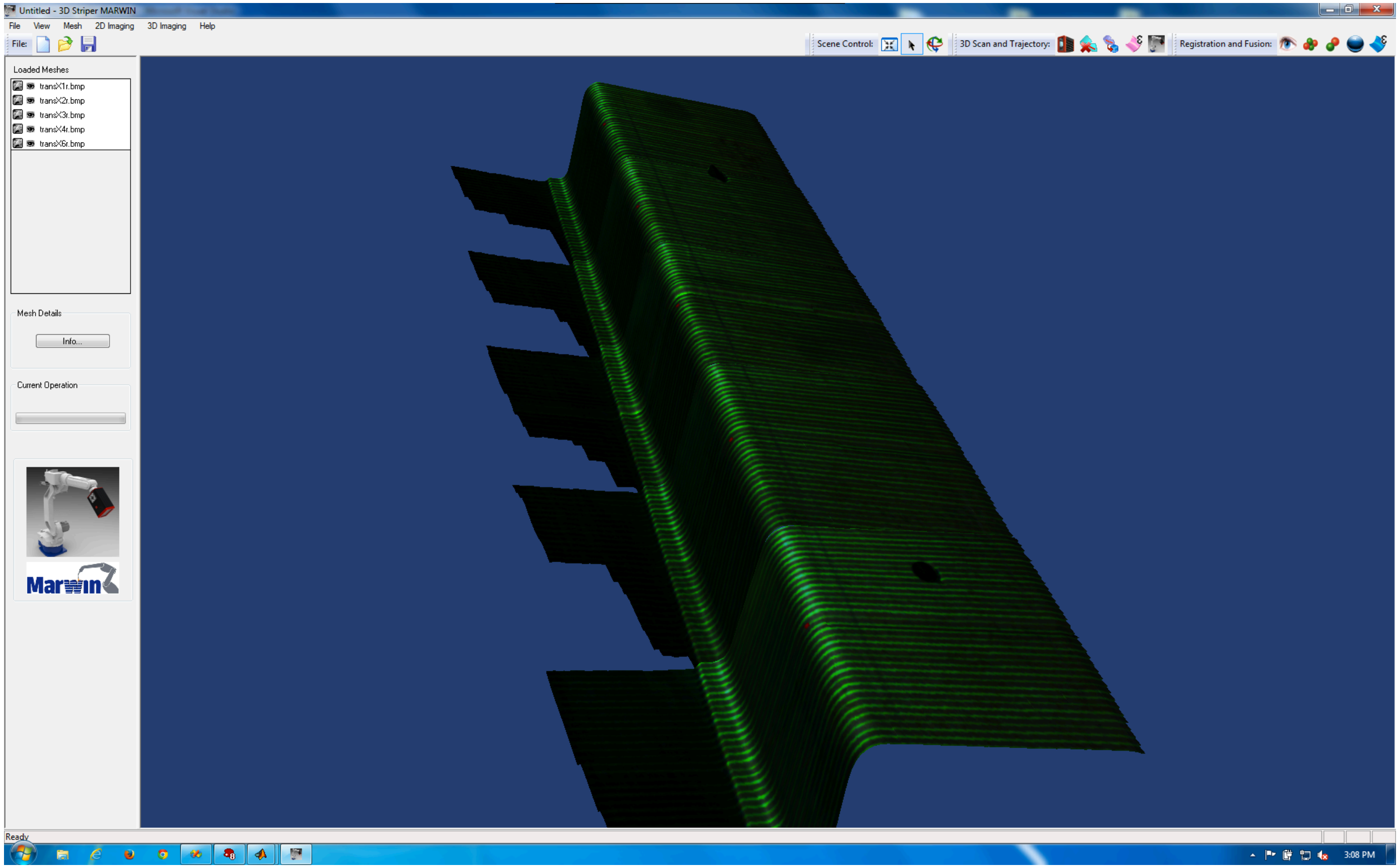
Scanning a part with the robot

As the robot moves the part is assembled



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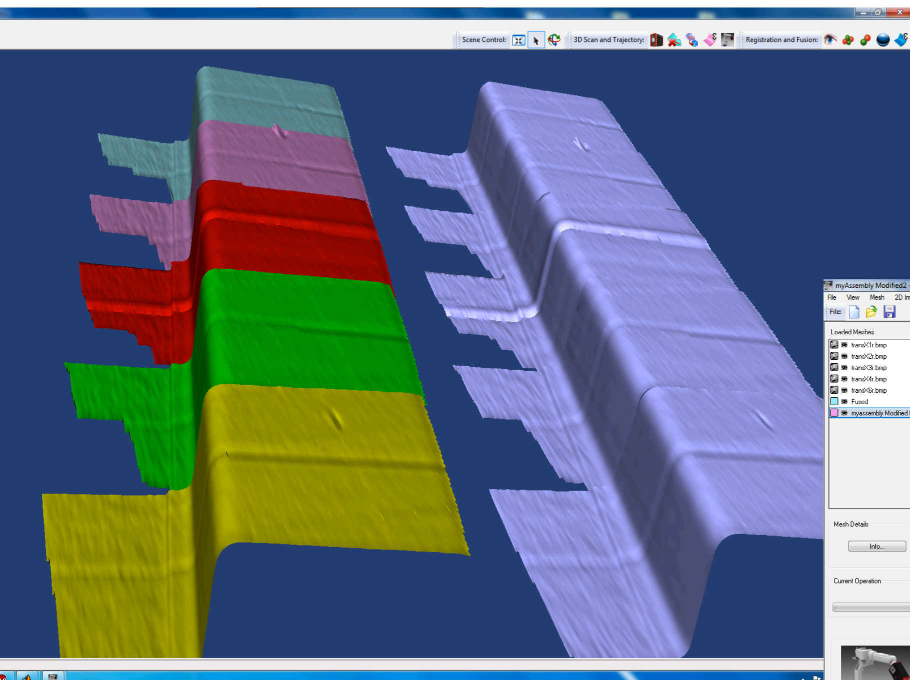
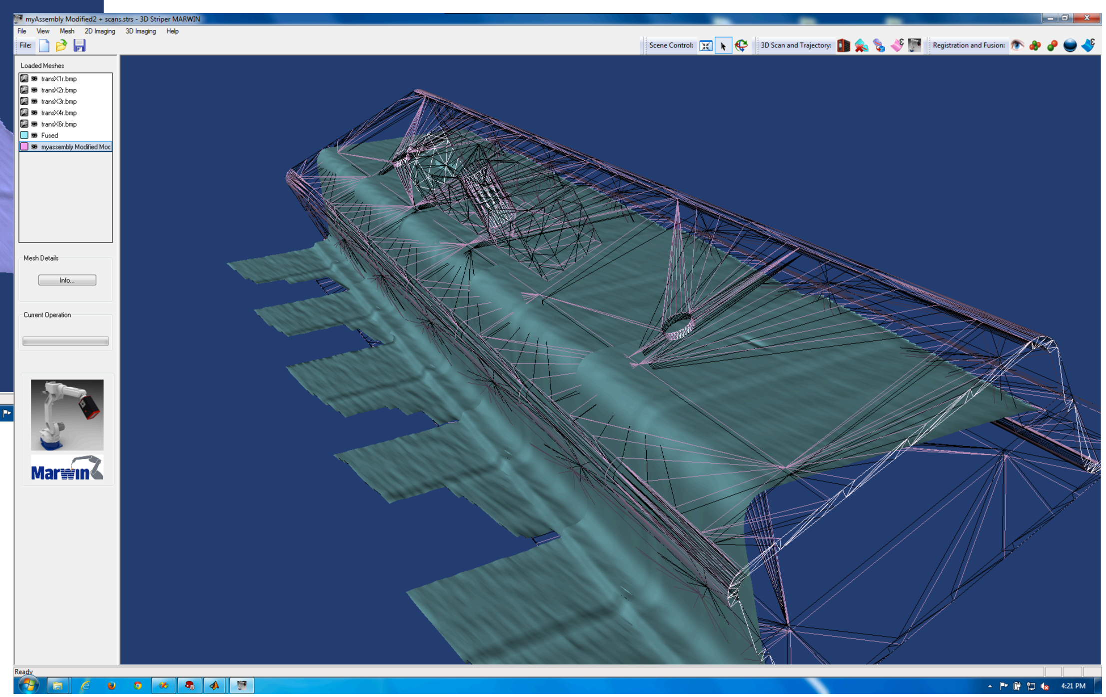
Automatic registration with CAD models

Scanned patches are fused and registered



Registration goal is to estimate R,t:

$$F(\mathbf{R},\mathbf{t}) = \sum_{i=1}^{m}\sum_{j=1}^{Ni} p_{i,j} d^2(\mathbf{R}p_{i,j} + \mathbf{t}, S_k) + \sum_{k=1}^{n}\sum_{l=1}^{Nk} q_{k,l} d^2(\mathbf{R}^T p'_{k,l} - \mathbf{R}^T\mathbf{t}, S_i)$$



Least squares minimisation:

$$f(\mathbf{R},\mathbf{t}) = \frac{1}{N}\sum_{i=1}^{N} ||\mathbf{R}\mathbf{p}_i + \mathbf{t}, \mathbf{q}_i||^2$$

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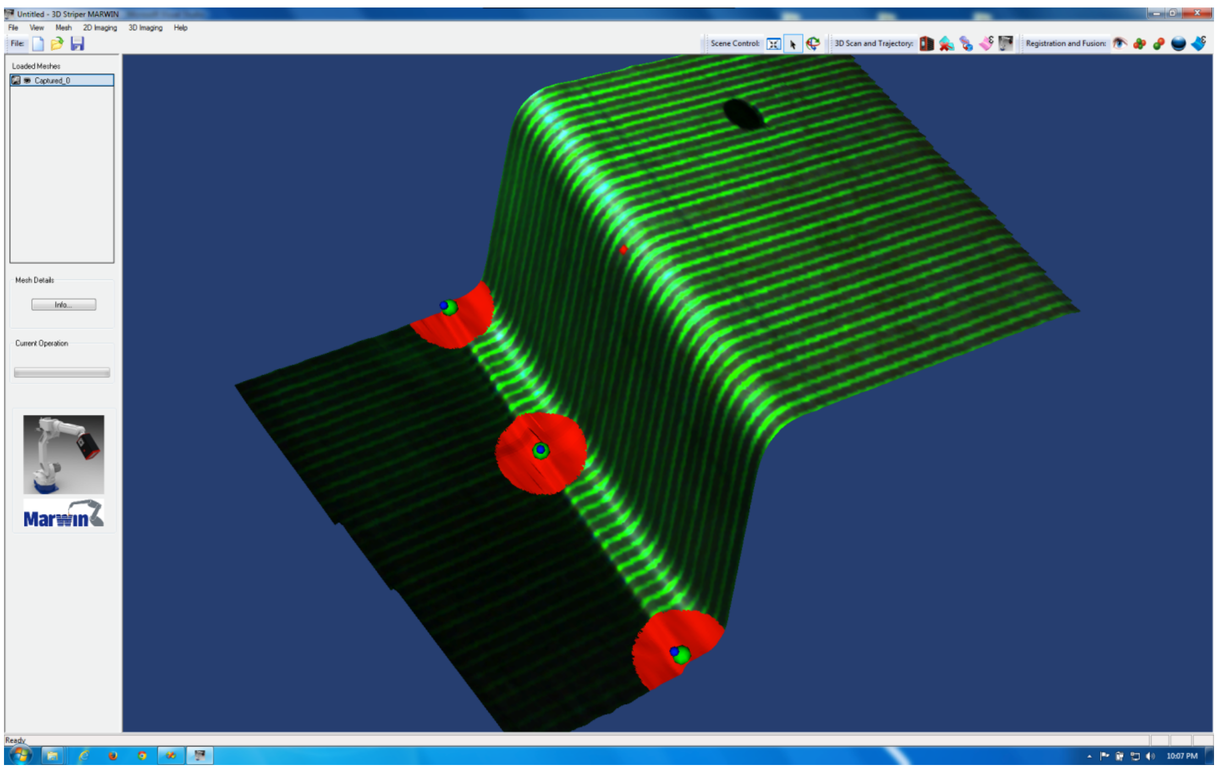
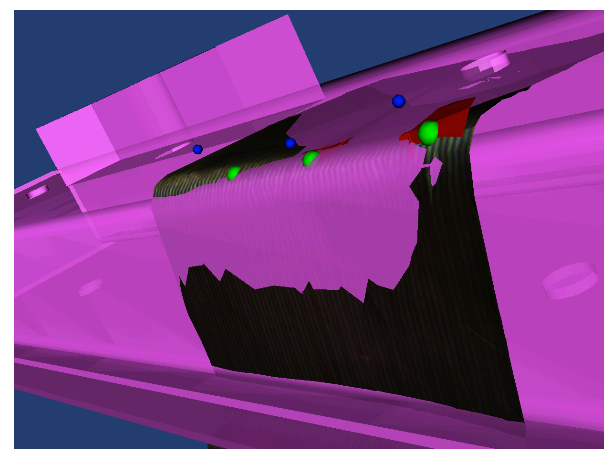
Welding sequence

Translated from CAD to scanned models





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The ADMOS Project

Gender classification and age estimation

Ateknea Solutions Hungary | RUBIN Informatikai Zrt. | FLEXIBLE OKO OPTICAL | impactmedia | X-TREME CREATIONS | CEERRC | Sheffield Hallam University

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ADMOS: SHU work on various tasks

Marcos Rodrigues, Mariza Kormann

Privacy Regulations
Modelling and System Design
Hardware and Electronics Design
Client Side Software Development: tracking, gender and age estimation
Dissemination

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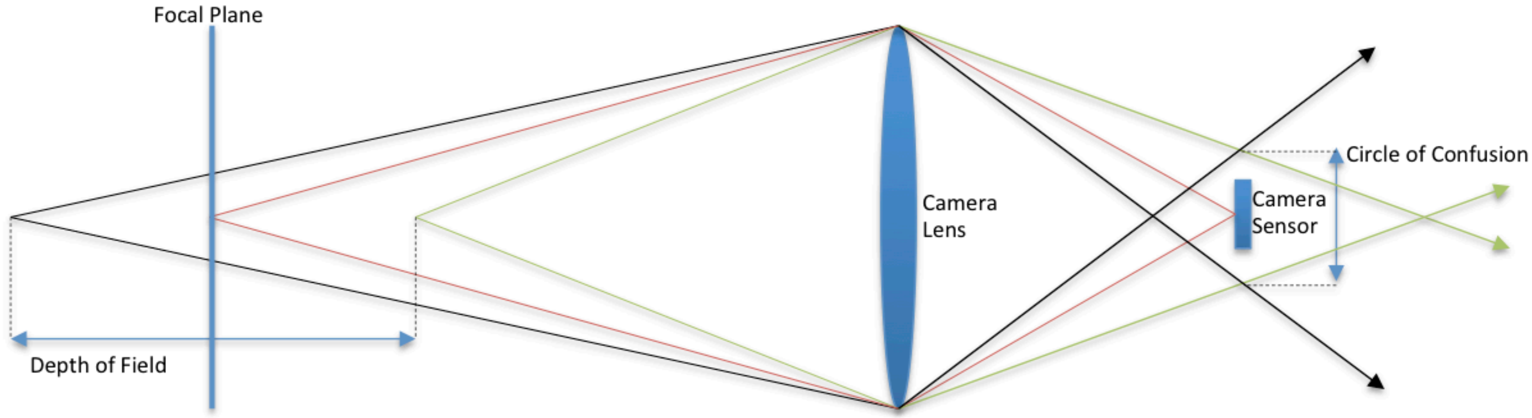
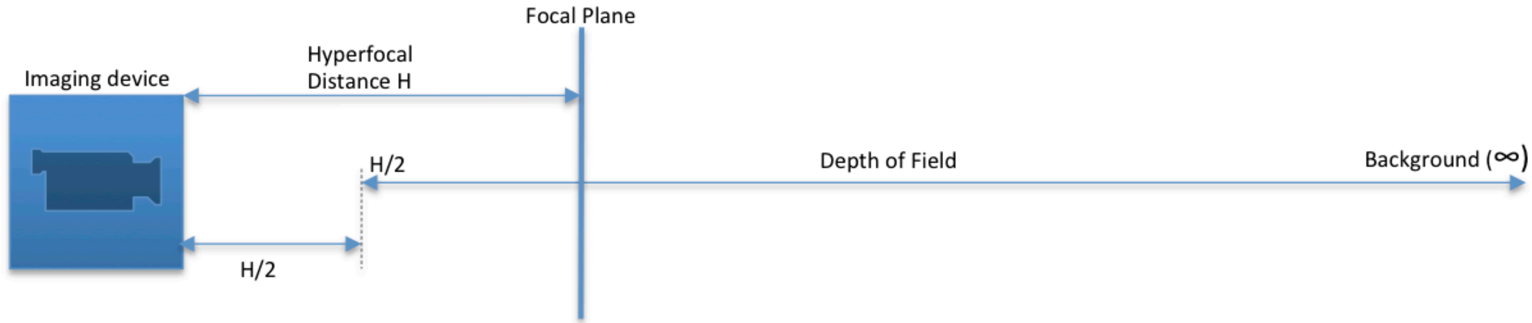
Hardware and Electronics Design

Optics and lighting

Optical lens and filters to ensure performance within various illuminating conditions





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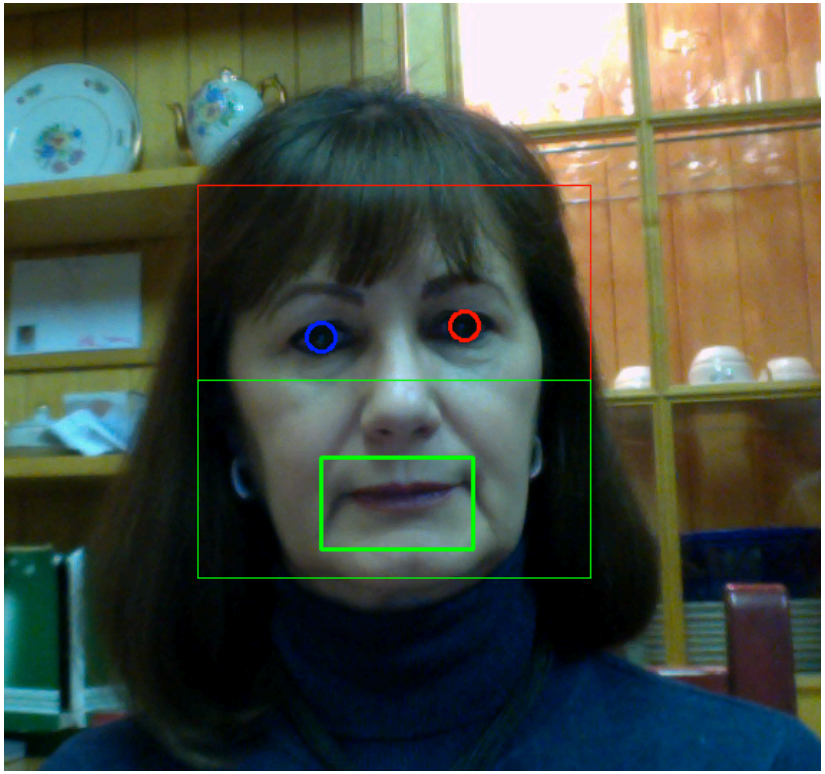
Client Side Software Development
Firmware and control s/w development

Real time processing:

1. *face detection and tracking*
2. *eye tracking*
3. *other feature tracking (mouth, nose)*
4. *cropping the various face-ROI*
5. *gender classification*
6. *age estimation*
7. *save statistical info to an xml file*
8. *transmit to server at periodic intervals*



Binary patterns
LBP, CT and MCT

Transformation	Decision function
$\mathrm{LBP}_{P,R} = \sum_{p=0}^{P-1} T(I_p - I_c) 2^p$	$T(.) = \begin{cases} 1 & \text{if } (I_p - I_c) \geq 0, \\ 0 & \text{otherwise.} \end{cases}$
$CT_{m,n}(x,y) \;=\; \Vert_{i=-n/2}^{n/2} \Vert_{j=-m/2}^{m/2} \; f(I(x,y), I(x+i, y+j))$	$f(u,v) = \begin{cases} 0 & \text{if } u \leq v, \\ 1 & \text{otherwise.} \end{cases}$

MCT is similar to CT, except that it uses the average intensity of the kernel window as the intensity of the centre pixel.

Applying binary patterns to face images
Visualizing the differences on images

Input image

LBP 3×3

Census 3×3

Modified Census 3×3

Census 5×5

Modified Census 5×5

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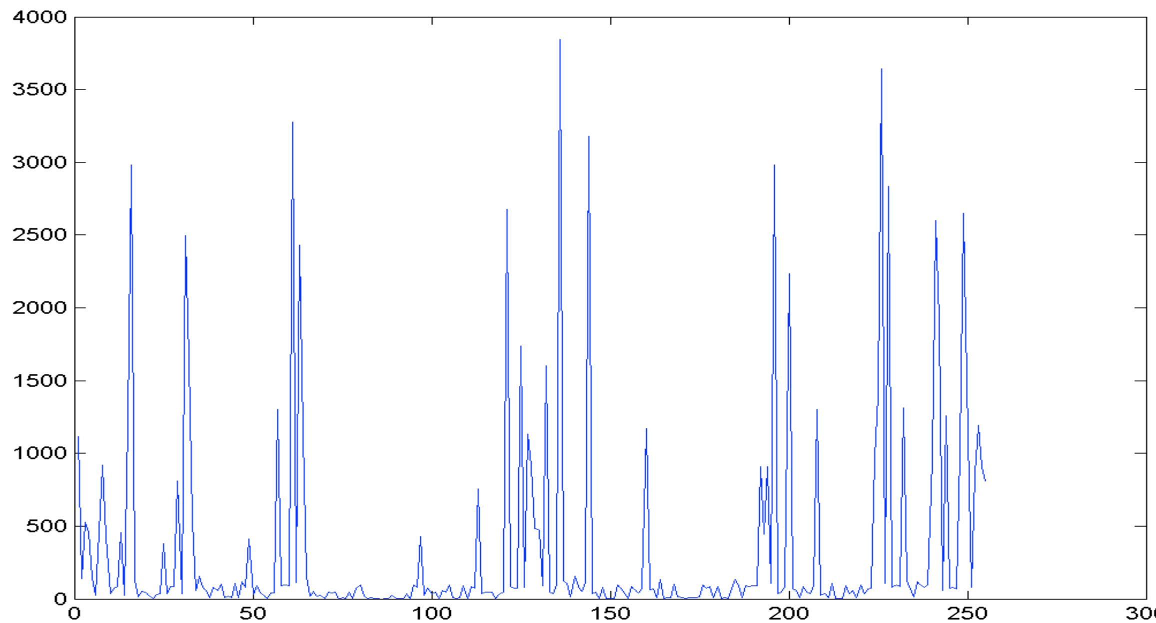
LBP processing
Features are defined by the histogram



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ROI sensitivity analysis

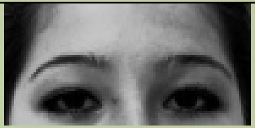
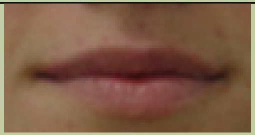
Male subjects tend to be classified with higher accuracy.

This agrees with all results reported in the literature.

No explanation for this behaviour is offered at this stage.

TABLE I

COMPARATIVE ANALYSIS OF IMAGE REGIONS

Image ROI	Gender	Classification results
 ROI1	Male Female	92% 79%
 ROI2	Male Female	83% 83%
 ROI3	Male Female	**88%** **88%**
 ROI4	Male Female	88% 71%
 ROI5	Male Female	<40% <40%

Comparative analysis of binary patterns

DCT-Discrete Cosine Transform

Decomposes a signal and defines it as a sum of cosines at different frequencies

$$y(k) = w(k) \sum_{n=1}^{N} z(n) \cos\left(\frac{\pi(2n-1)(k-1)}{2N}\right)$$

$$k = 1, 2, \ldots N$$

$$w(k) = \begin{cases} 1/\sqrt{N} & \text{for } k = 1, \\ \sqrt{2/N} & \text{for } 2 \le k \le N. \end{cases}$$

The length of coefficients y is the same size as the original signal z.

Comparative analysis of binary patterns

DWT-Discrete Wavelet Transform

$$x(n)\,h(n) = \sum_{k=-\infty}^{\infty} x(k)\,h(n-k)$$

$$y(n) = \sum_{k=-\infty}^{\infty} h(k)\,x(2n-k)$$

$$y_{\mathrm{high}} = \sum_{n} x(n)\,g(2k-n)$$

$$y_{\mathrm{low}} = \sum_{n} x(n)\,h(2k-n)$$

$$x(n) = \sum_{k=-\infty}^{\infty} (y_{\mathrm{high}}(k).g(-n+2k))\,(y_{\mathrm{low}}(k).h(-n+2k))$$

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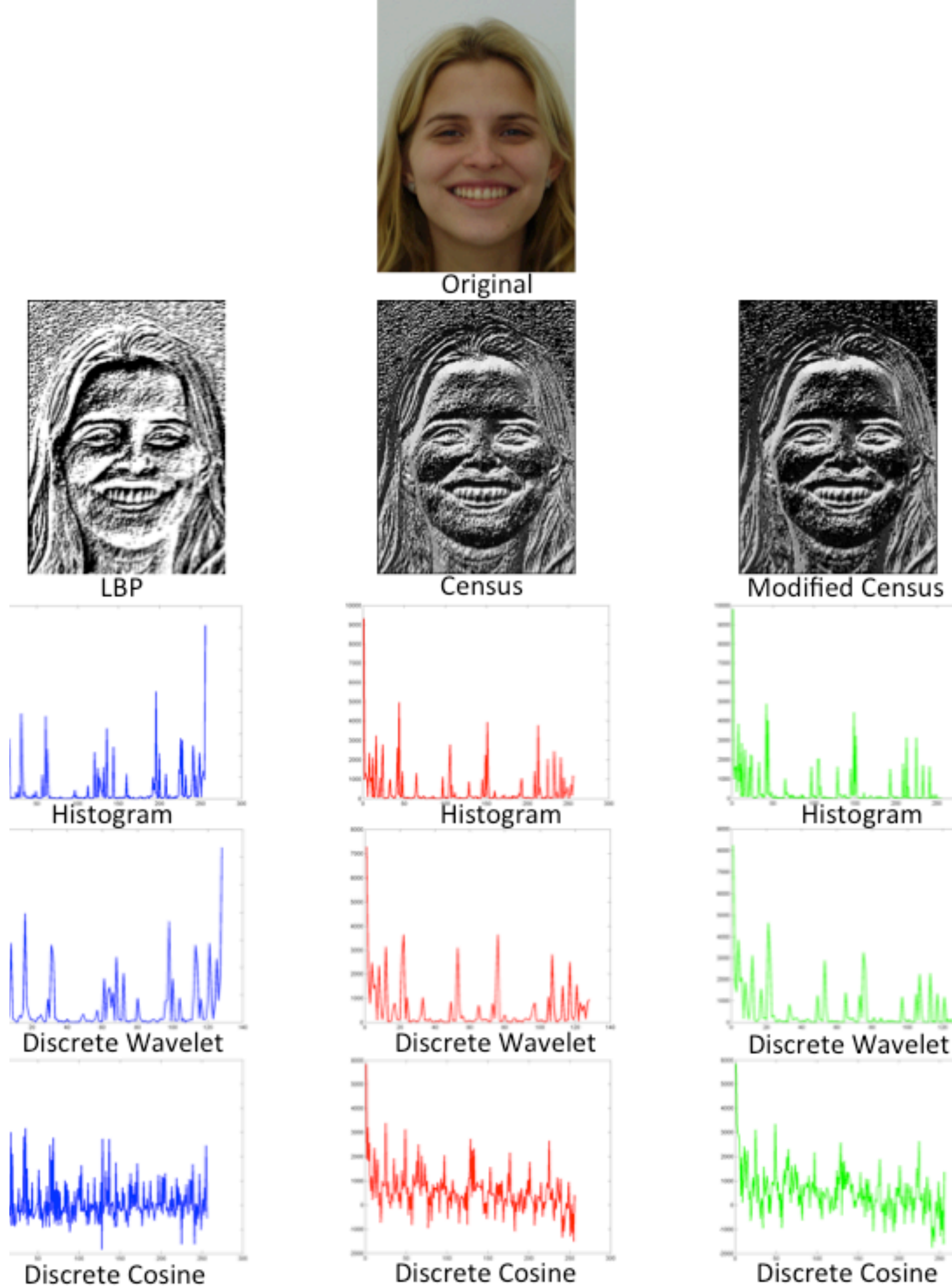
Comparative analysis of binary patterns

Raw histograms

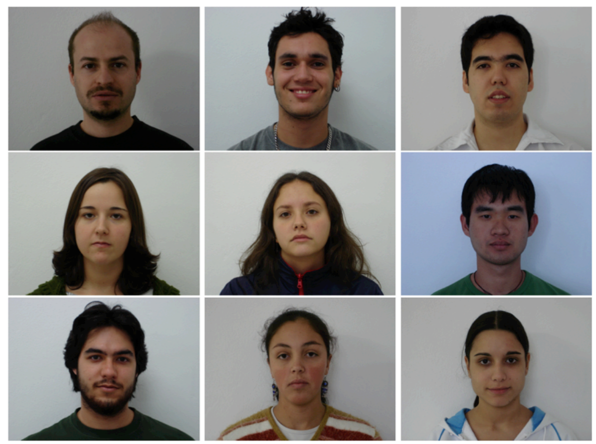
Transformed histograms by DCT

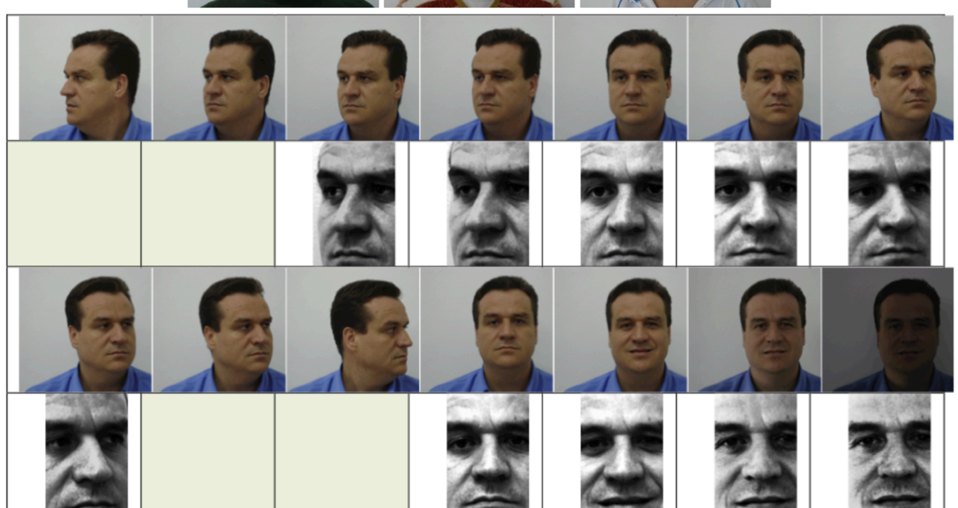
Transformed histograms by DWT



Tested on public databases

FEI, AT&T, Sheffield-UMIST, and color FERET





Classification results
Average for 4 Regions of Interest

	LBP	CT	MCT	LBP||CT	LBP||MCT
FEI Database					
LBP&Census	87.9	87.6	79.0	86.3	85.2
DWT	85.2	84.4	79.0	86.3	84.1
DCT	86.8	89.8	81.2	87.4	85.7
AT&T					
LBP&Census	66.4	65.3	50.0	77.9	50.0
DWT	59.1	50.0	50.0	69.6	50.0
DCT	84.2	87.0	90.1	83.2	80.3
Sheffield-UMIST					
LBP&Census	81.6	82.8	67.8	78.7	68.4
DWT	77.2	78.0	73.2	75.8	83.6
DCT	84.6	84.3	83.0	86.5	85.2
Color FERET					
LBP&Census	69.5	68.1	70.3	67.9	70.6
DWT	71.5	72.0	67.1	72.4	69.6
DCT	71.9	68.8	70.9	73.1	73.6

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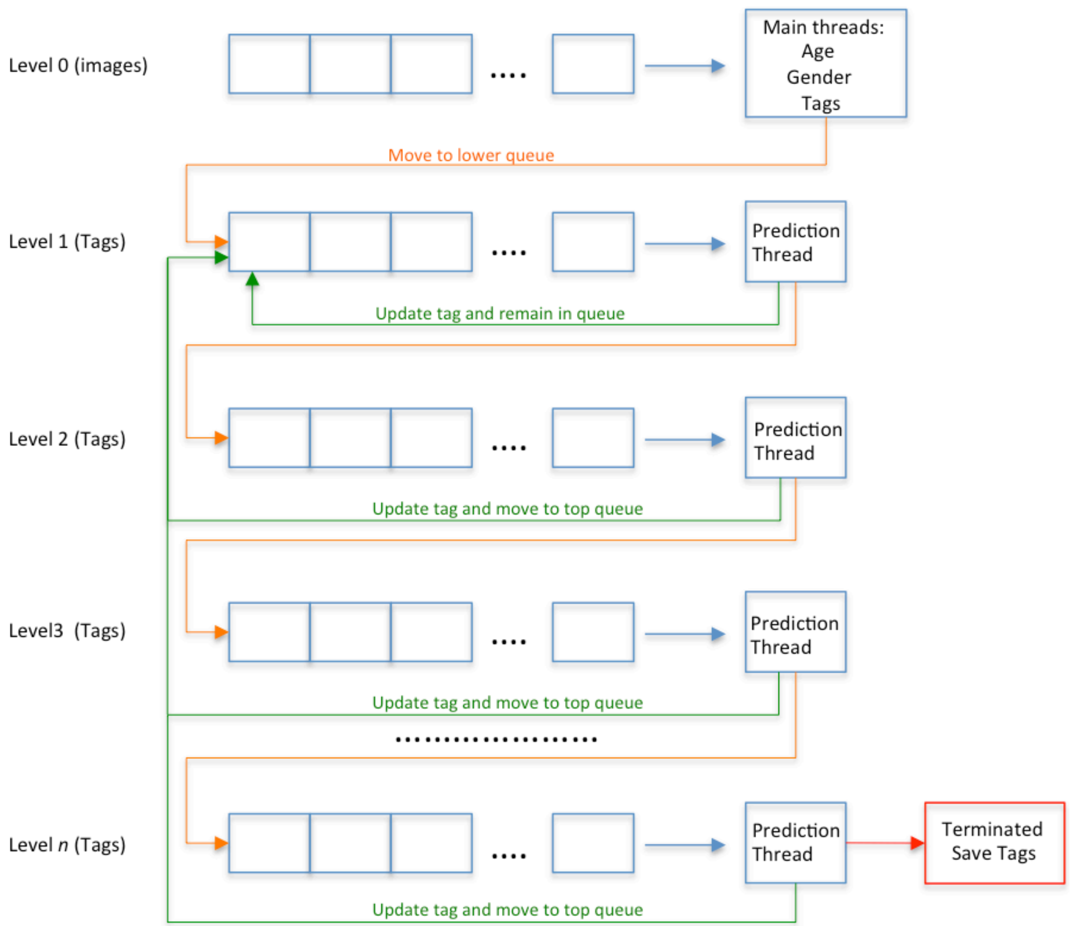
Real time and privacy requirements
Define and track anonymous tags



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Conclusions

LBP + Eigenvector decomposition: top half of the face most significant

Binary patterns + SVM: LBP is slightly superior to CT/MCT

Binary patterns + DCT + SVM: CT is clearly the superior technique
Also, bias towards male subjects is removed
CT has the smallest standard deviation of all techniques

Real-time performance: enabled by multiple threads using multi-level queues

Testing in shopping malls in Hungary and UK in June and July 2015