# Through connectivity in applied computer systems – ADMOS and MARWIN projects

RODRIGUES, Marcos <http://orcid.org/0000-0002-6083-1303> and KORMANN, Mariza

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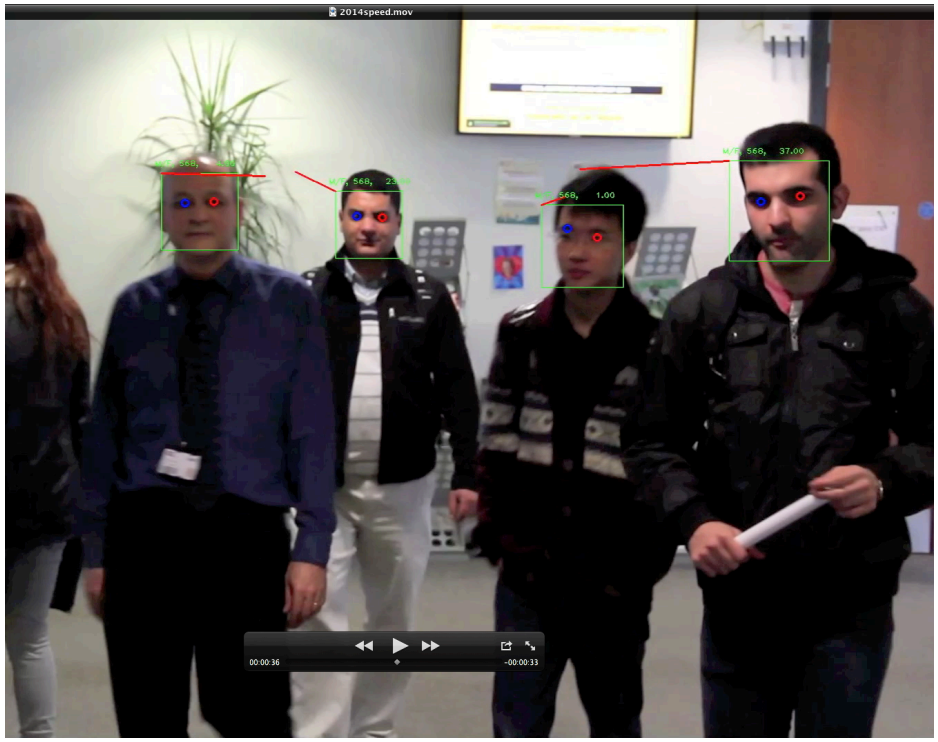
# Through Connectivity in Applied Computer Systems – ADMOS and MARWIN Projects

*Marcos Rodrigues*



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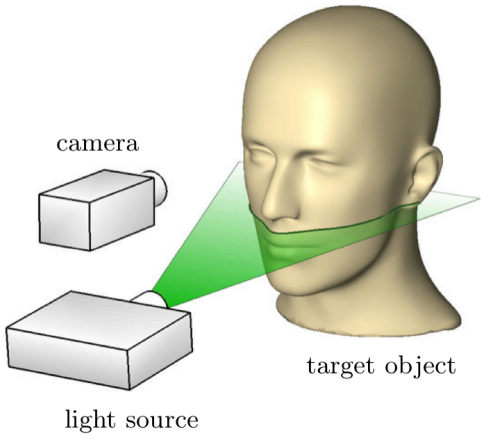
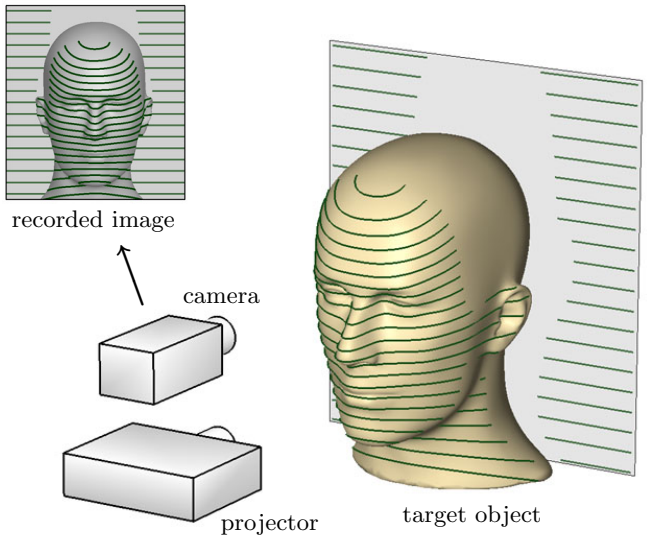
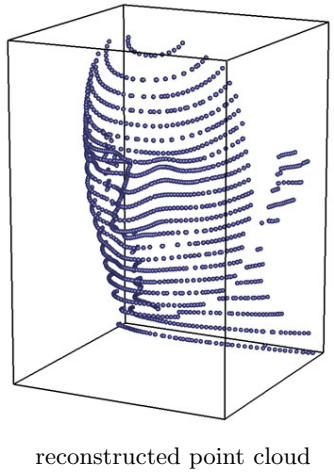
# The GMPR 3D scanning technologies
## *3D with single image*




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 The Intelligent Choice

ROLAN ROBOTICS

G-ROBOTS

RECAMLÀSER

Sheffield Hallam University

MFKK Invention and Research Center Ltd.

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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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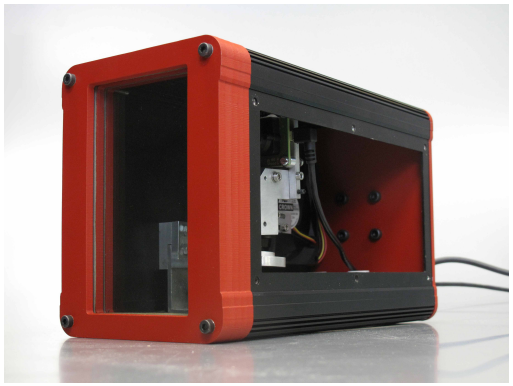
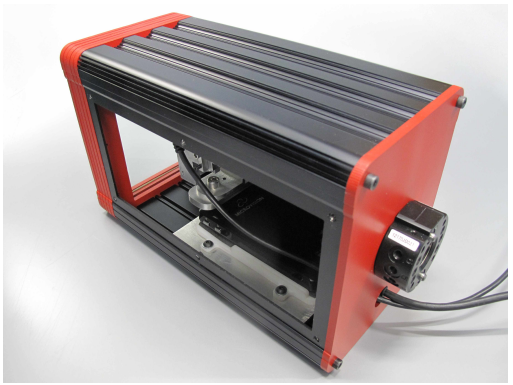
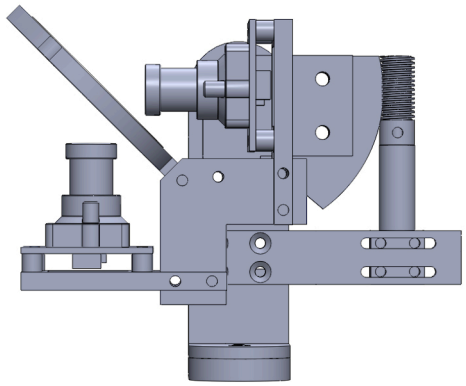
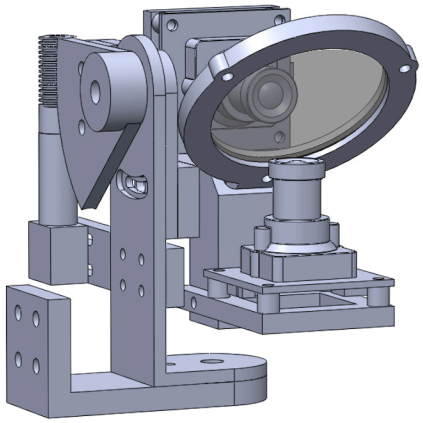
## GMPR scanner design

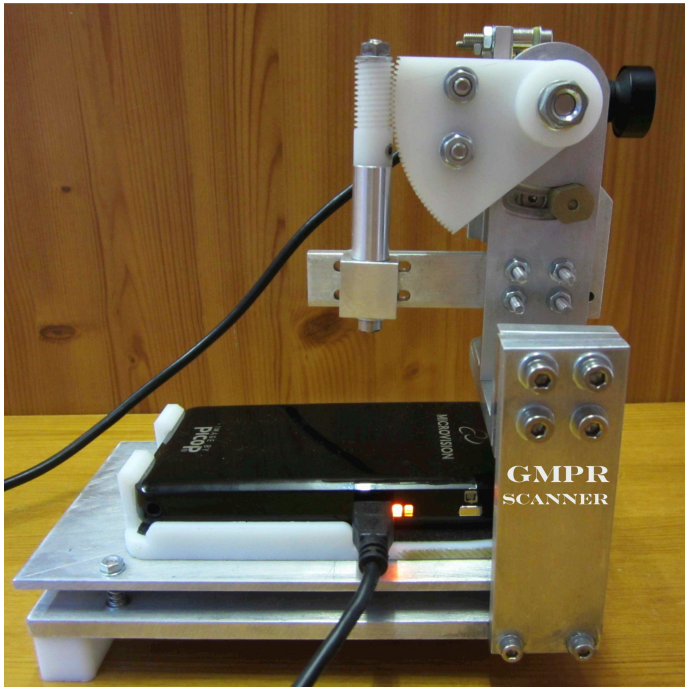
*A beam splitter allows for visible and near-infrared cameras to be fitted*












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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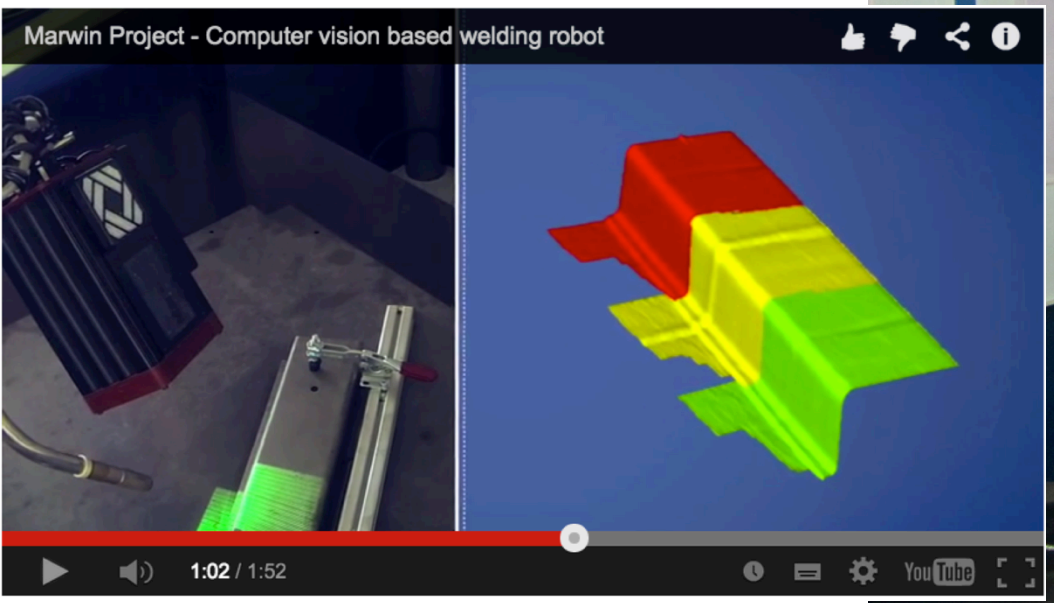
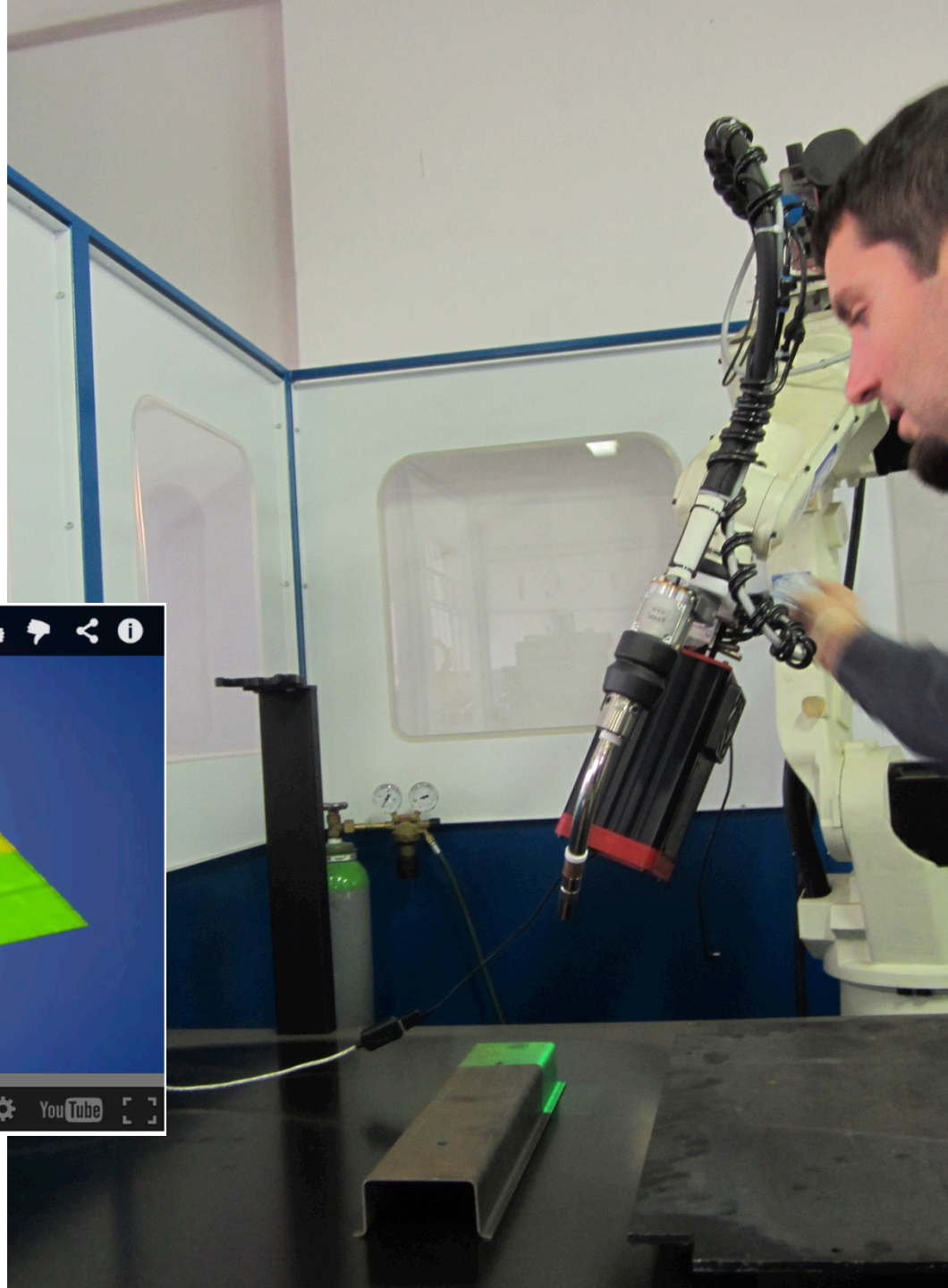
## Scanning a part



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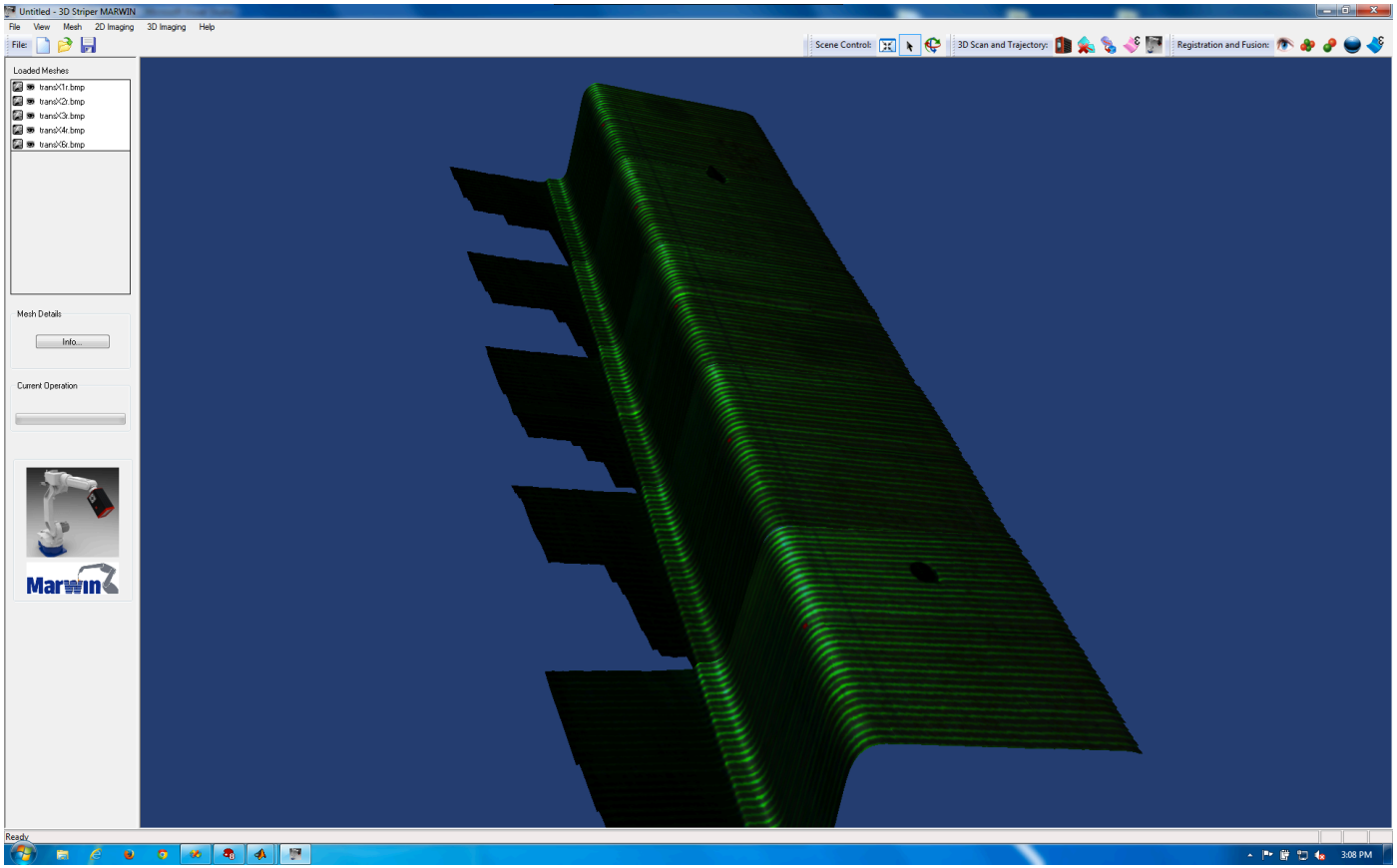
# Scanning a part with the robot

## *As the robot moves the part is assembled*



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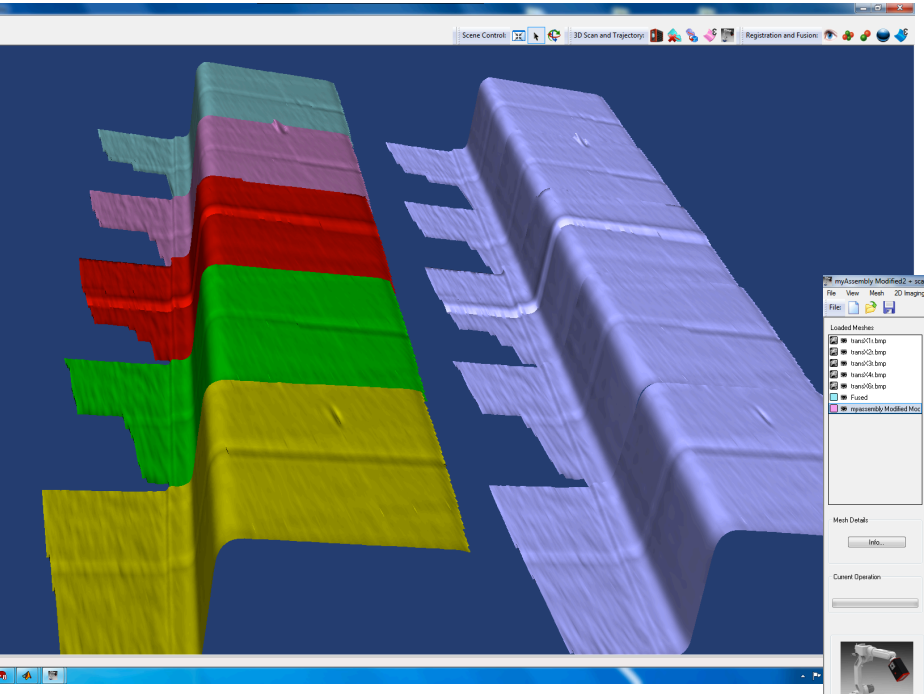
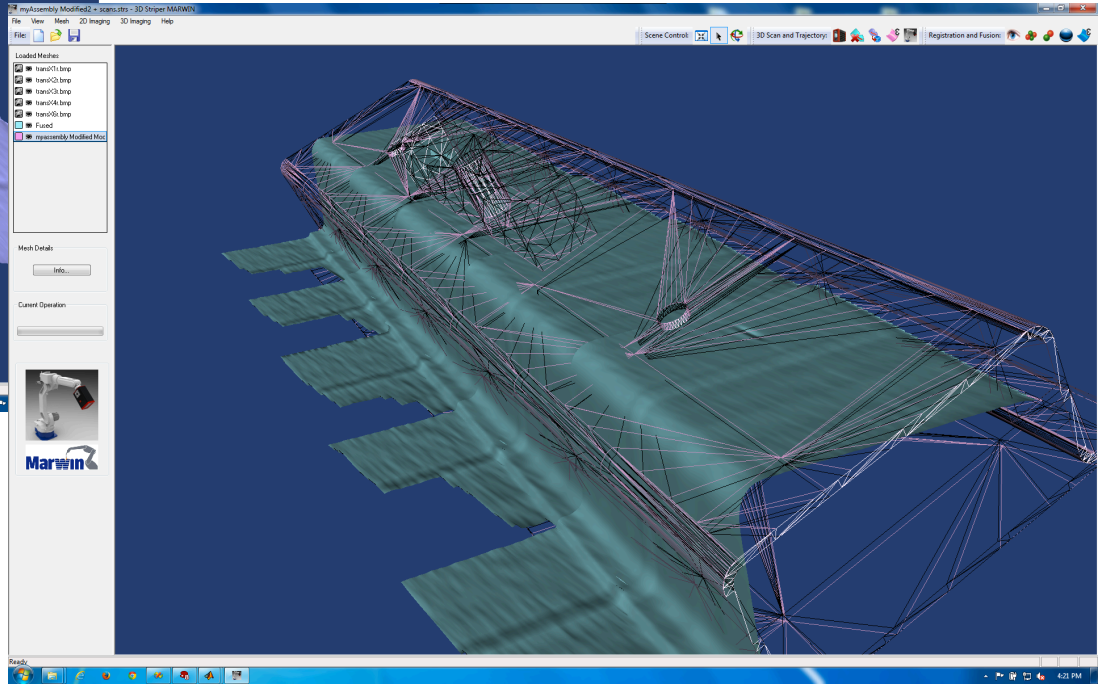
# Automatic registration with CAD models

## *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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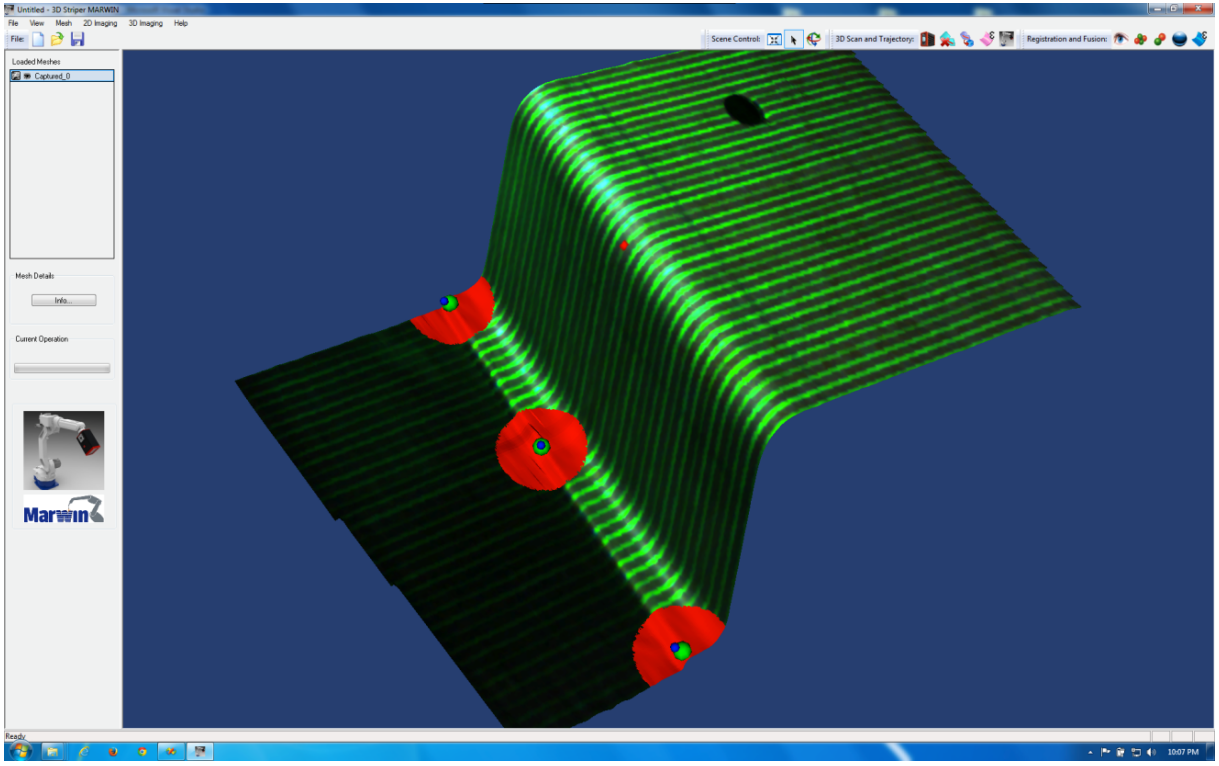
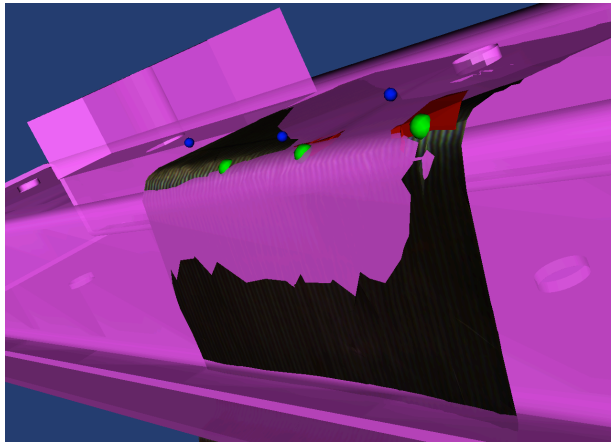
# Welding sequence
## *Translated from CAD to scanned models*



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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

CEERC

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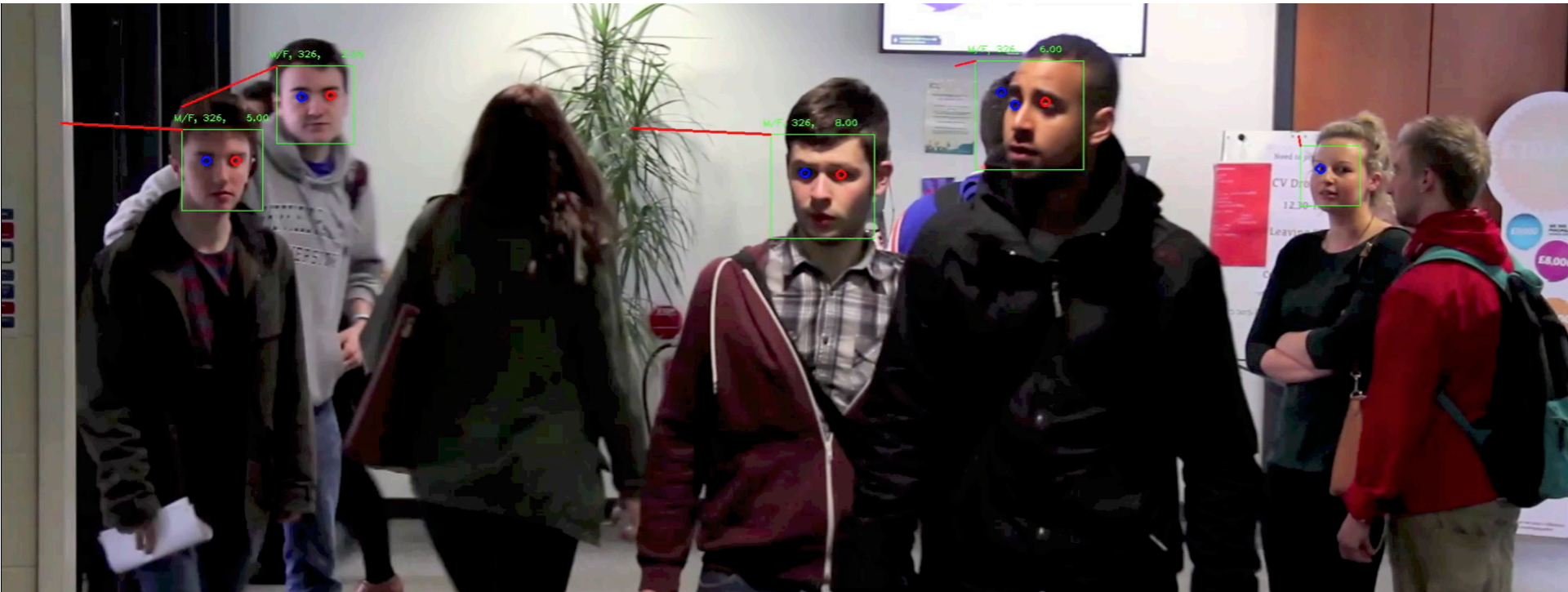

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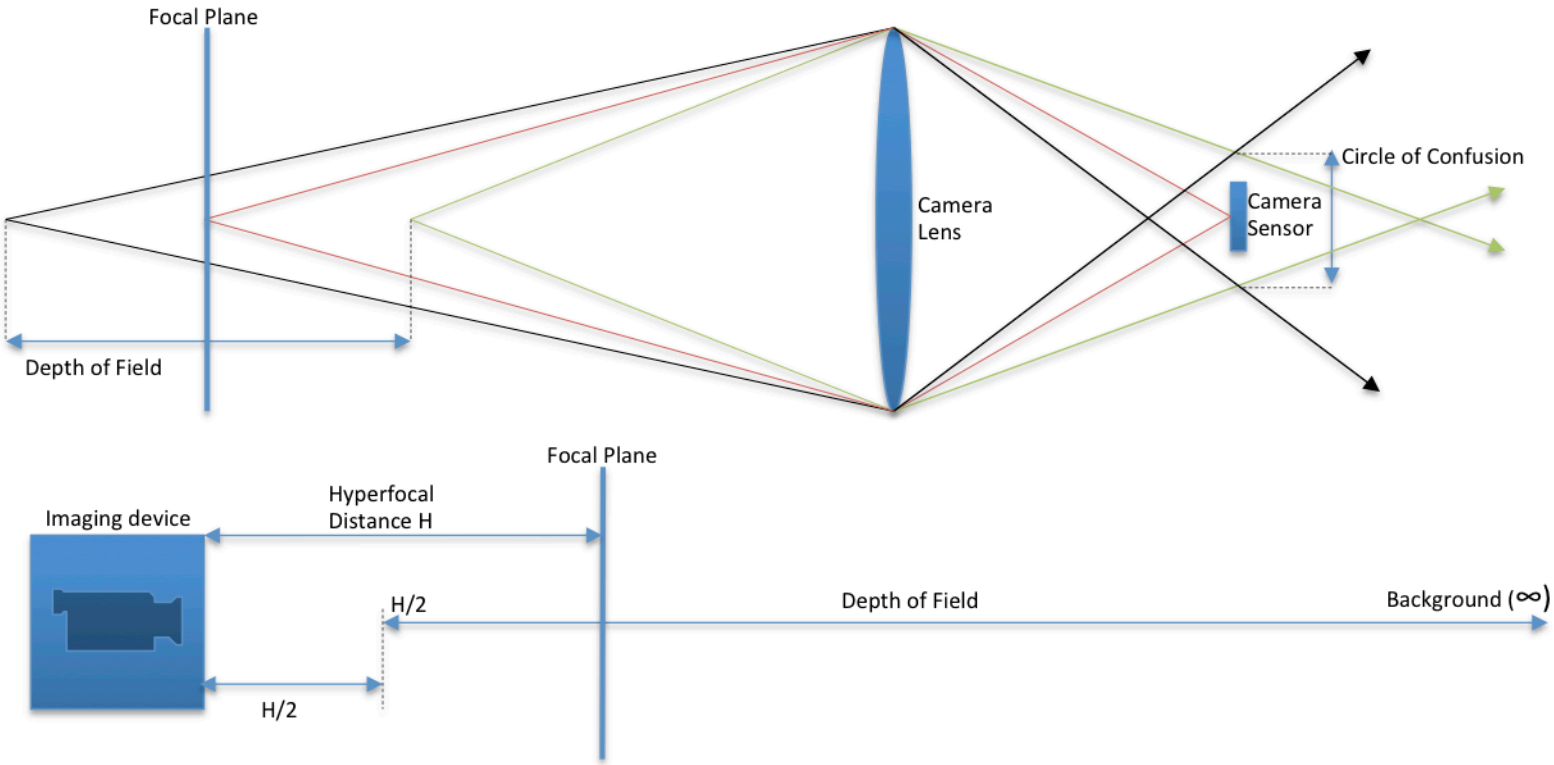
# ADMOS: SHU work on various tasks

*Marcos Rodrigues, Mariza Kormann*

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

# 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)*

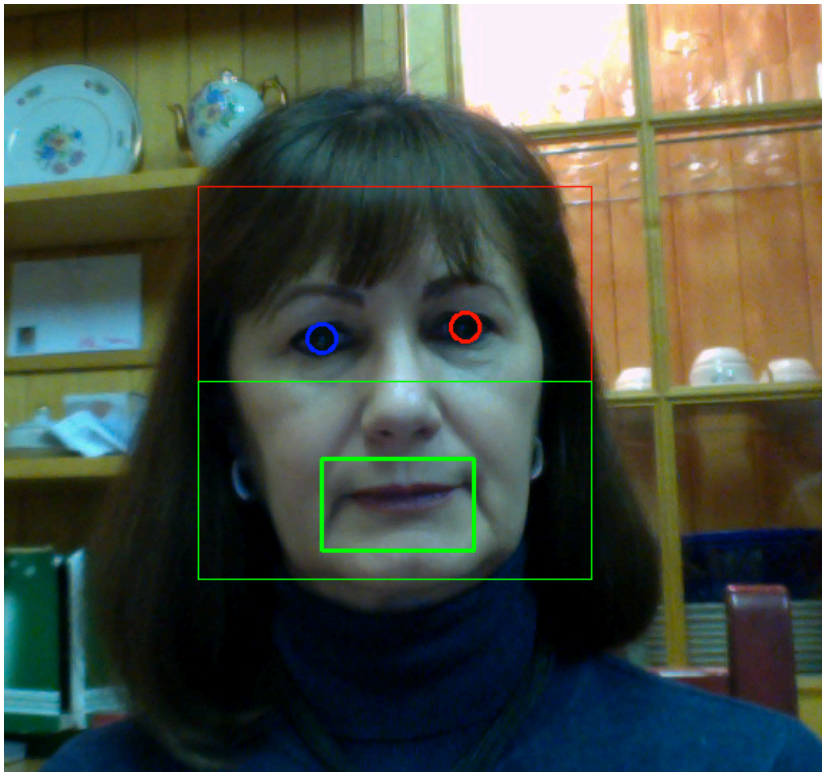
*4. cropping the various face-ROI*

*5. gender classification*

*6. age estimation*

*7. save statistical info to an xml file*

*8. transmit to server at periodic intervals*



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# Binary patterns
## *LBP, CT and MCT*

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

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

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# Applying binary patterns to face images
## *Visualizing the differences on images*

Input image

LBP 3×3

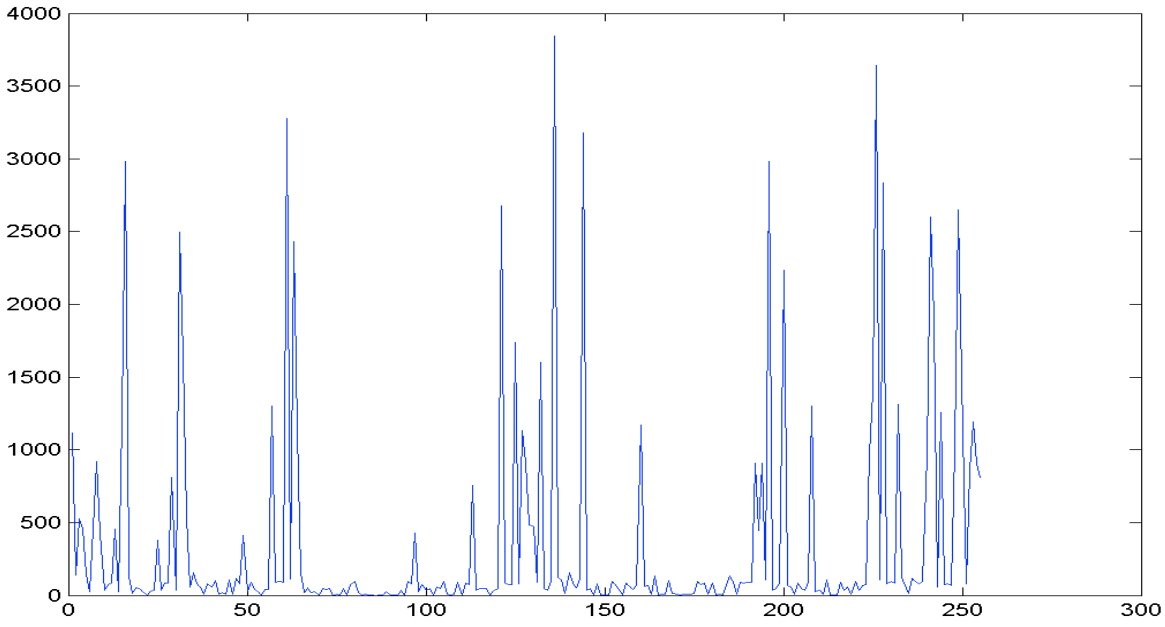
Census 3×3

Modified Census 3×3

Census 5×5

Modified Census 5×5

# LBP processing
## *Features are defined by the histogram*



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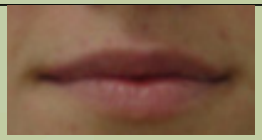
## ROI sensitivity analysis

*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<br>Female | 92%<br>79% |
|  ROI2 | Male<br>Female | 83%<br>83% |
|  ROI3 | Male<br>Female | **88%**<br>**88%** |
|  ROI4 | Male<br>Female | 88%<br>71% |
|  ROI5 | Male<br>Female | <40%<br><40% |

# Comparative analysis of binary patterns
## *DCT-Discrete Cosine Transform*

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

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

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

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

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

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# Comparative analysis of binary patterns
## *DWT-Discrete Wavelet Transform*

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

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

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

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

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

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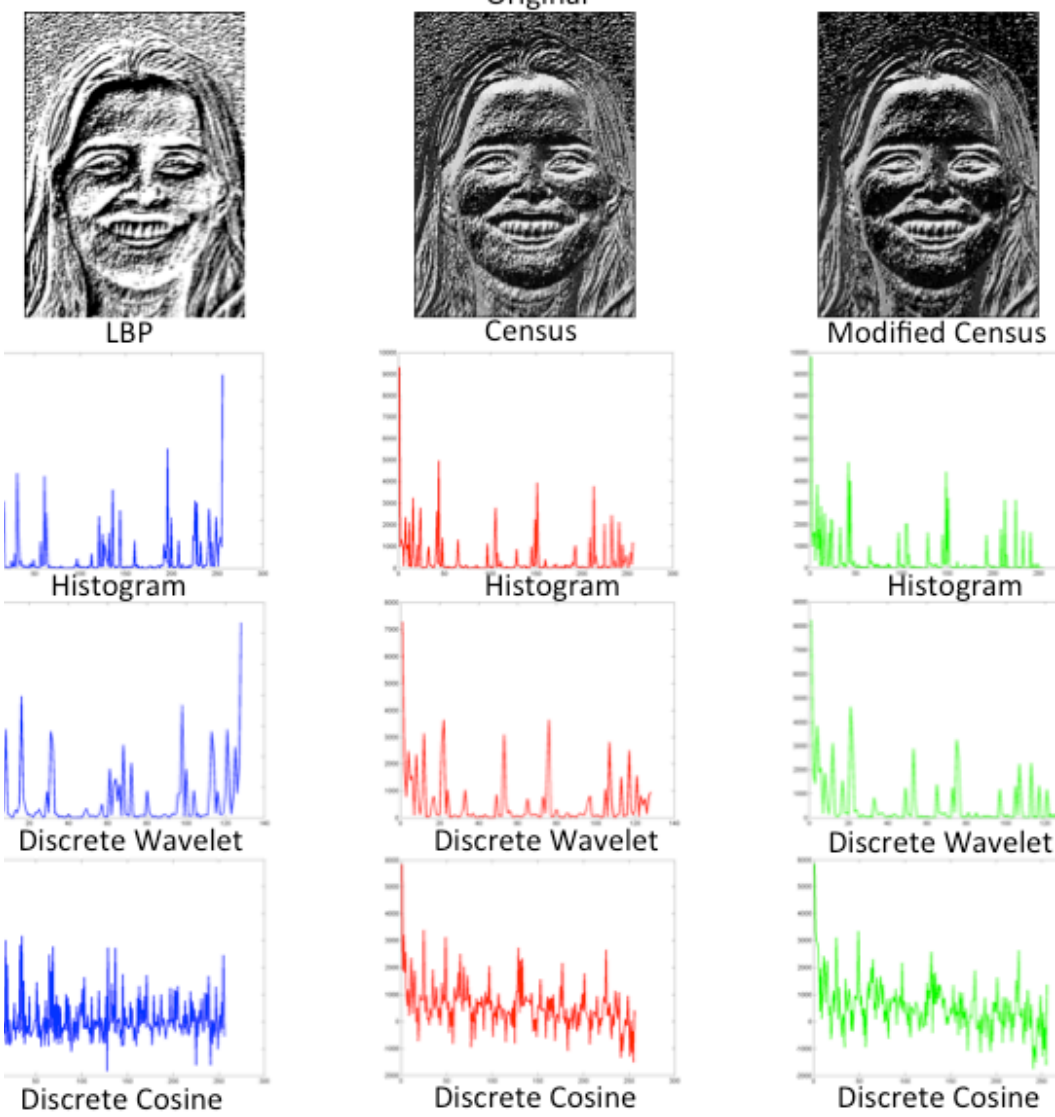
# Comparative analysis of binary patterns

*Raw histograms*

*Transformed histograms by DCT*

*Transformed histograms by DWT*

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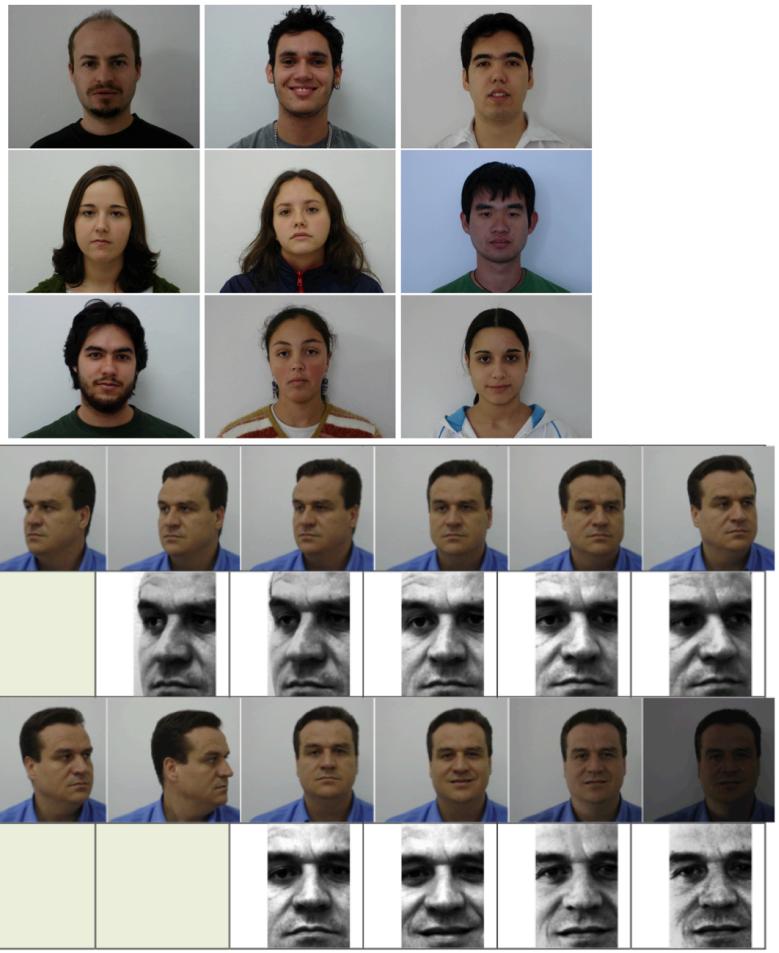
# Tested on public databases
## *FEI, AT&T, Sheffield-UMIST, and color FERET*



# 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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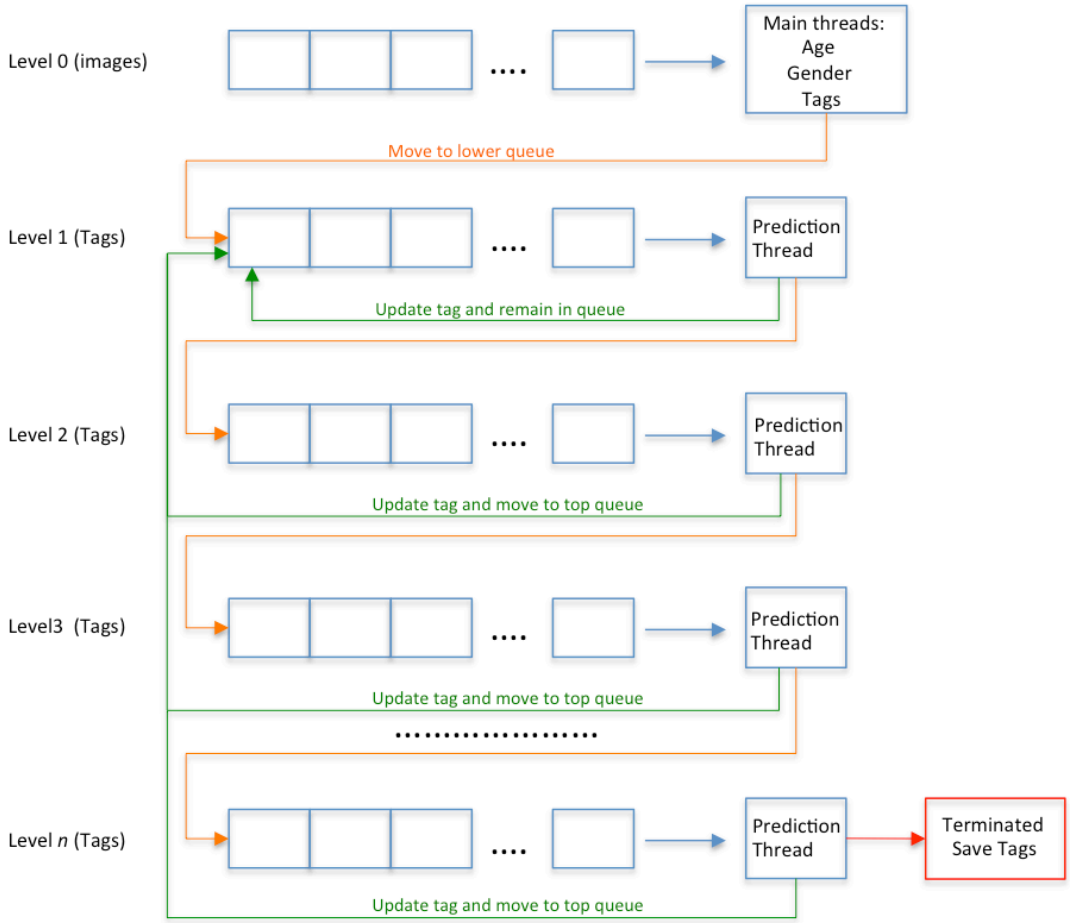
# Real time and privacy requirements
## *Define and track anonymous tags*



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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