Face Reading Technology for Lie Detection

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Background – how this project came about

- 2 and 1/2 year research project funded by EPSRC supported by UK Border Agency

- Partners are Bradford (visual) Aberystwyth (thermal) and QinetiQ (psychology and statistical analysis).

Aim was..

- To develop a completely non-invasive technology for lie/guilt detection
- System should be purely based on reading cues from the face (nothing else).
- An modern alternative to polygraph
- Can be used in covert situation (without the subject being aware)

Background

Polygraph

- Developed in 1921
- measures and records several physiological indices such as blood pressure, pulse, respiration and skin conductivity
- Tries to find correlation between these measurements

What's Wrong with Polygraph?

- It is highly invasive
- Very slow (requires several experts)
- Cannot be used in covert operations
- We don't believe it is a 21st century technology!

The Basics of our Proposed System

- A standard video camera (JVC-GY-HM100E)
- High resolution thermal camera (FLIR SC7000)
- Computer algorithms

Some psychology

- Generally, humans have very poor ability in detecting deceit and hostile intent, with accuracy rate of 40-60% (Burgoon et. al. 1994)
- Nonverbal behaviour are not as easily censored or disguised as the content of speech (Darwin, 1872), behavioural scientists investigated nonverbal behaviour
- Even though behavioural signs of nervousness could indicate simply nervous or concerned about issues in one's personal life, they must not be ignored as they could indicate that the person has more sinister intent

Some psychology...

- Particular behaviours can indicate particular mental states
- The behavioural signs of deception both voluntary and involuntary clues that can happen simultaneously
- Facial behaviour that indicates an individual is experiencing a particular specific emotion is hard to determine. However, some cues to hide alternative expressions/feelings are not easily disguised

Assumptions

When one is being deceitful she/he is making up something in the brain. This results in increased brain activity.

This results in increased physiological responses which can be measured on the face (including facial blood flow pattern).

Assumptions ...

- Humans do not possess the ability to control the physiological response to emotions.
- Stress causes abrupt changes in local skin temperature and distinctive facial signatures.
- The periorbital region around the eye is associated with specific emotions in the moments after the detection of a threatening stimulus.

The Visual Domain

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What we look for in the Visual Domain

- Humans have a well defined “rigid” skull structure and facial muscle structure

- This means there are finite number of facial expressions a human can perform

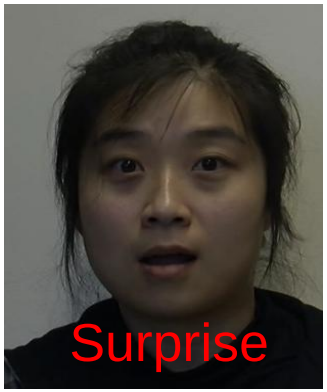
- These are called Facial Action Units (FACS) and 46 such Action Units.

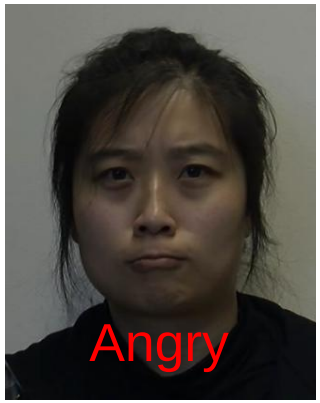
What we look for in the Visual Domain

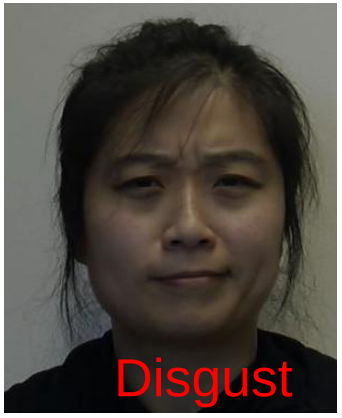
- We extract the Facial Action Units from the video
- We classify and categorise them
- We identify patterns
- Compare these patterns (with the “normal” facial behaviour of the subject)

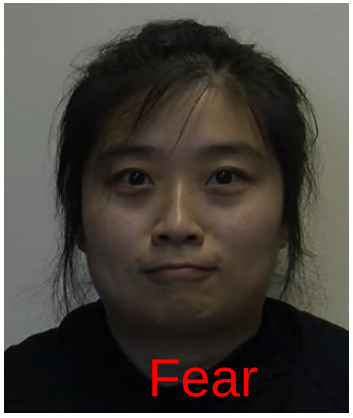
We also look for specific facial signatures which are known to be associated with strong emotions

Visual Analysis on Face









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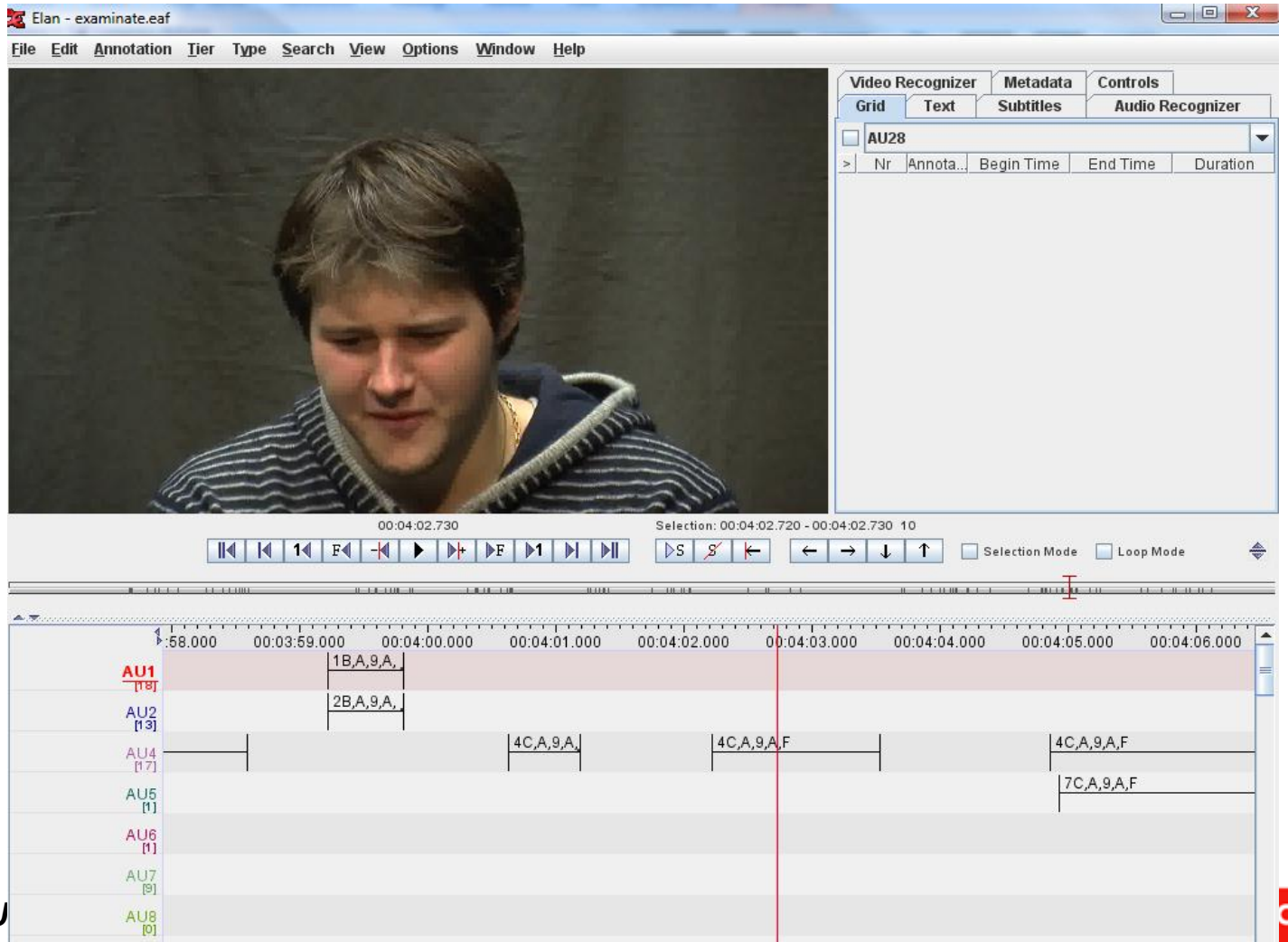
Annotation of Face Activities



Example of Action Units Labelling

The list of AUs in our in-house database

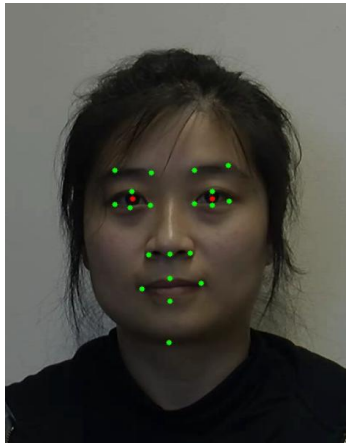
Type	Meaning
AU1	Inner Brow Raise
AU2	Outer Brow Raise
AU4	Brow Lowerer
AU5	Upper Lid Raiser
AU6	Cheek Raise

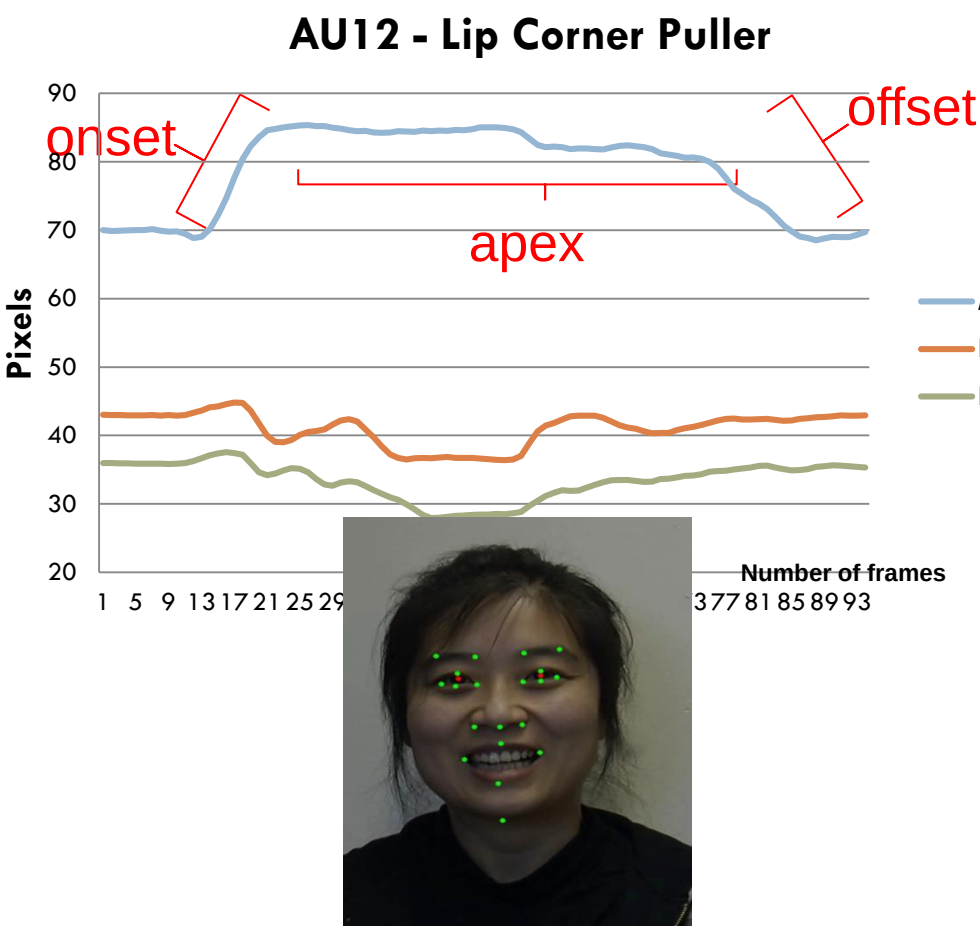
Type	Meaning
AU50	Speech
AU51	Head Turn Left
AU52	Head Turn Right
AU53	Head up
AU54	Head Down

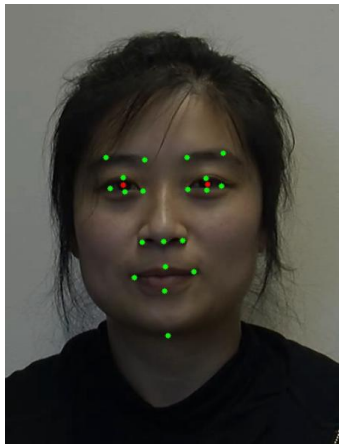
AU31	Jaw Clencher
AU32	Bite
AU33	Blow
AU36	Tongue Bulge
AU37	Lip wipe
AU38	Nostril Dilate

AU100	*Head tilt left and right*
AU101	*Hand on neck*
AU102	*Heavy breath*
AU103	*Forehead muscles*
AU104	*Lip pucker to the left*
AU105	*Lip pucker to the right*

Facial Action Analysis







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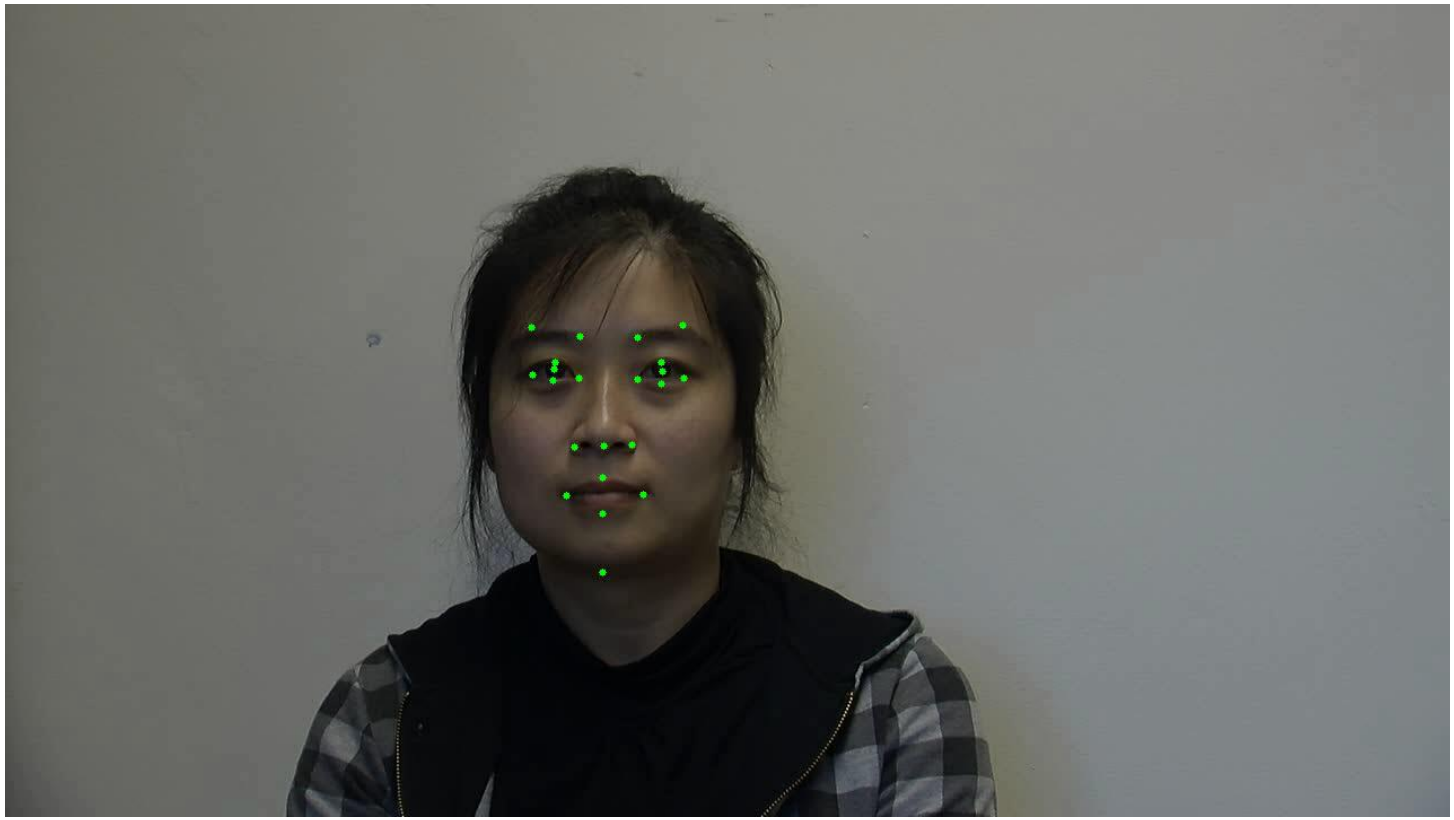
Facial Action Analysis



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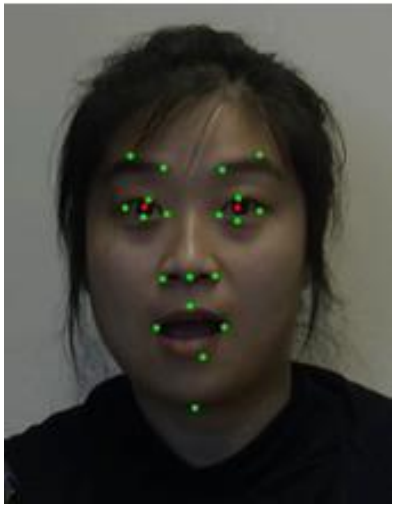
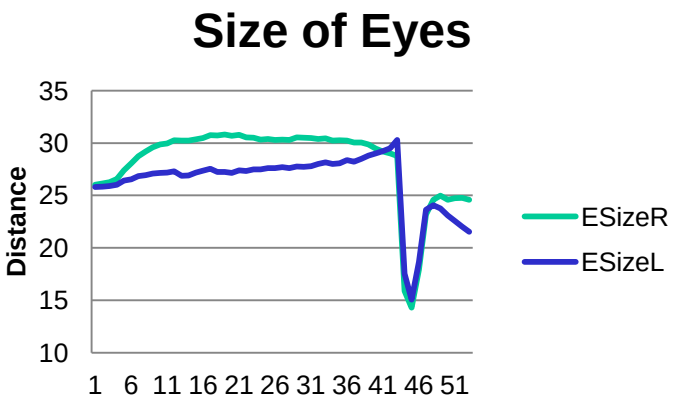
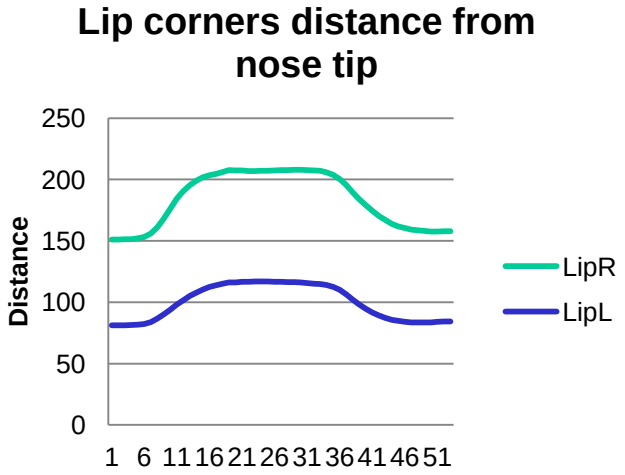
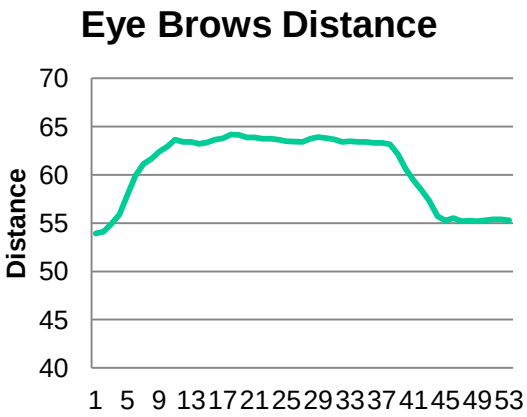
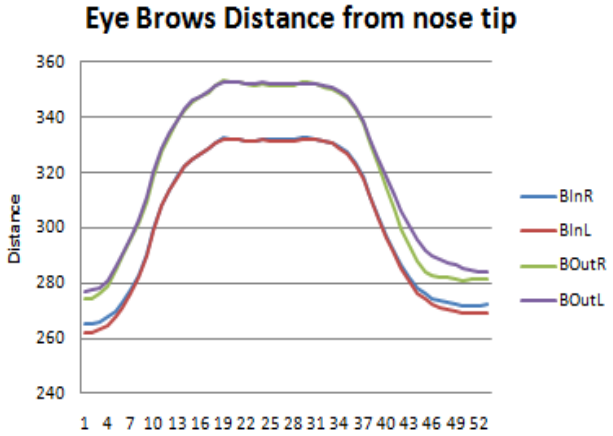
Facial Action Analysis

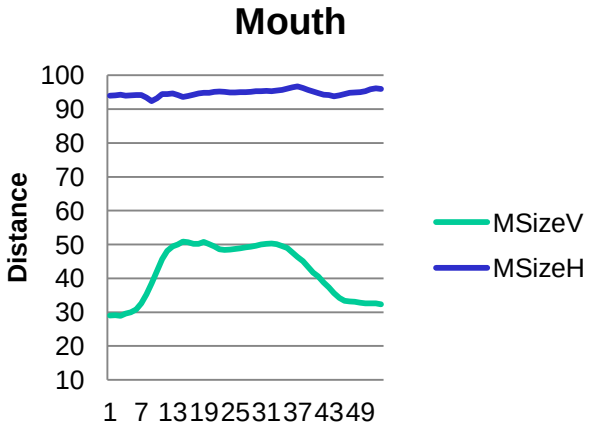












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Facial Cues (from literature and own experiments

- Lip biting
- Micro-expressions
- Frequent swallowing
- Slips of the tongue
- Joint/merged expressions
- Asymmetry in the face
- Duration of the expression
- Dilated pupils
- Fewer facial movements
- Blink rate

Other visual expressions

Visual Cue – Slip of the tongue

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Visual Cue – Swallowing

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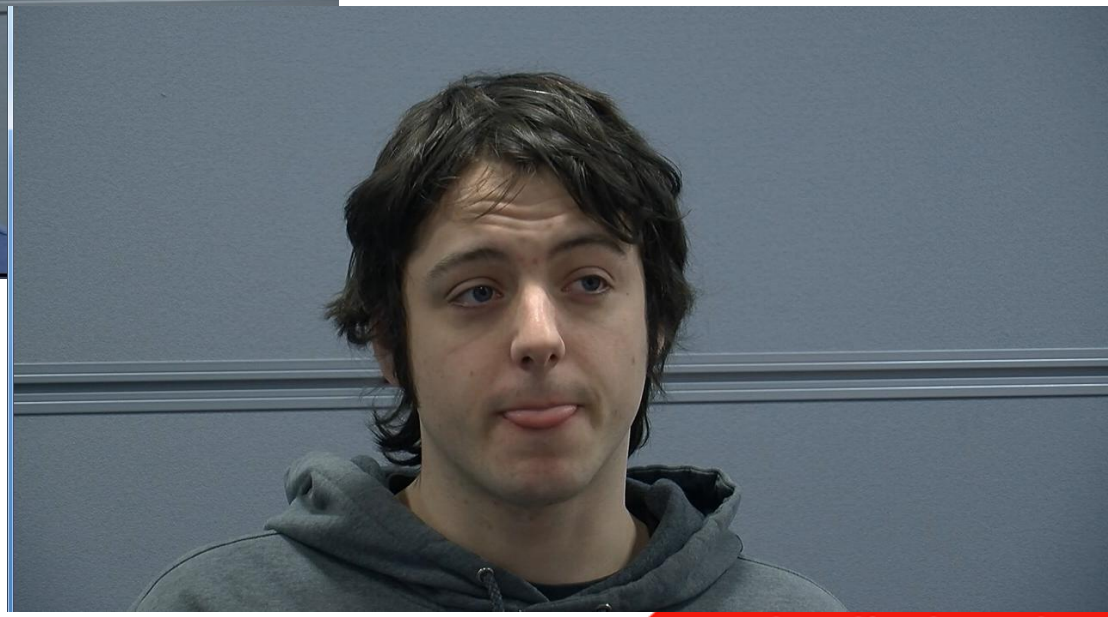
Visual Cue – Lip bites, Lip wipe



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The Thermal Domain

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What we look for in the Thermal Domain

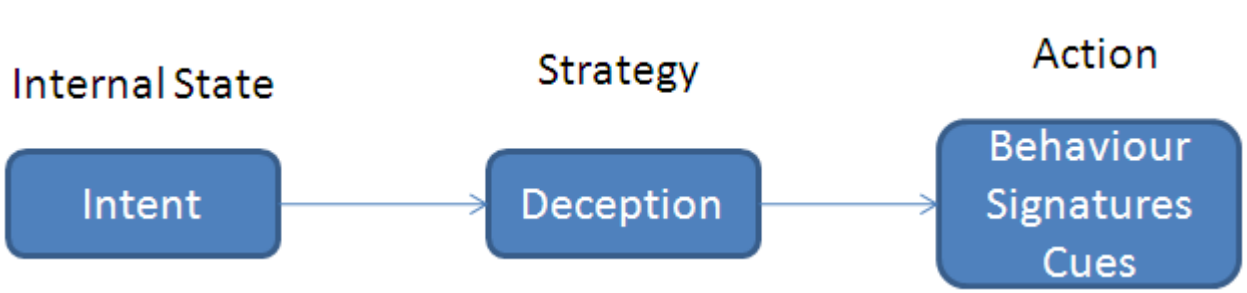
- We look for changes in the blood flow pattern on the face (especially around the eye)

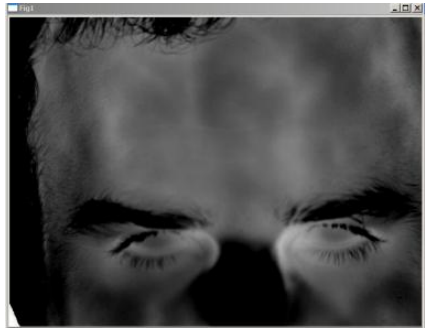
- Through thermal imaging we can identify and track individual blood vessels and blood flow pattern within them.

The thermal Modality

Questions

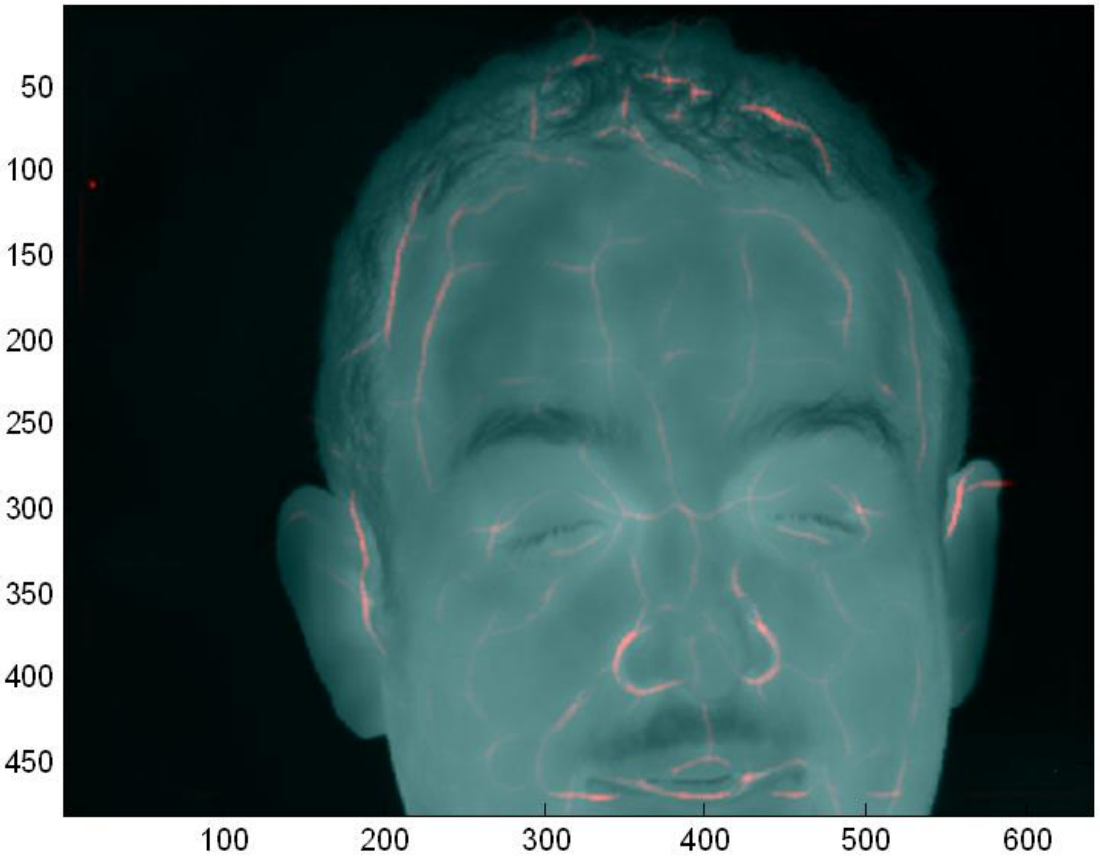
- Are there reliable thermal indicators of deceit?
- can we establish a one-to-one correspondence between facial thermal patterns and deception?
- will it be feasible to deploy machine vision to detect, in an unambiguous way, specific activities of interest?





Potential Advantages

- A major limitation with visual-based approaches is that they might fail to detect true emotion as some humans can mask their true emotion through these modes. Therefore other modalities need to be considered. Besides, linking behaviour to expression of specific emotions involve detailed measures of facial muscles, which is very hard.
- Methods based on using thermal imaging have the potential to outperform traditional polygraph measures. Skin temperature is affected by microcirculation and might relate to behavioural aspects.
- Large physiological responses would indicate an assumed suspect involvement in deception



Active Thermal Differentials and Blood Vessels Distribution

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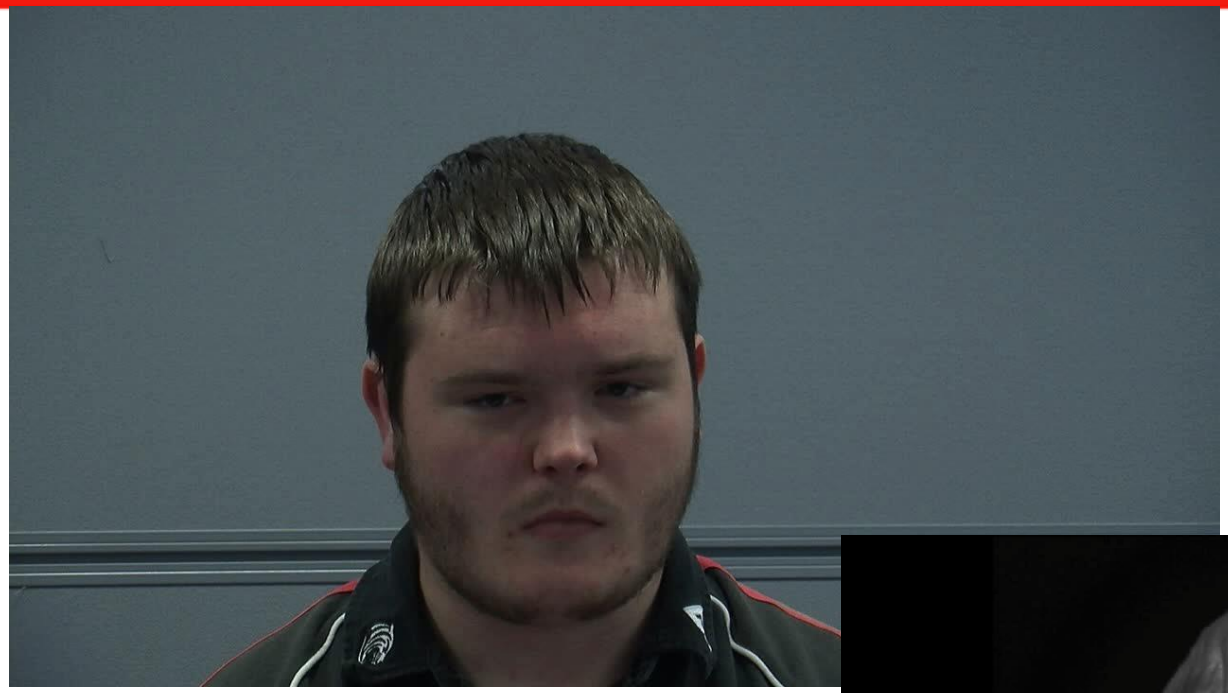

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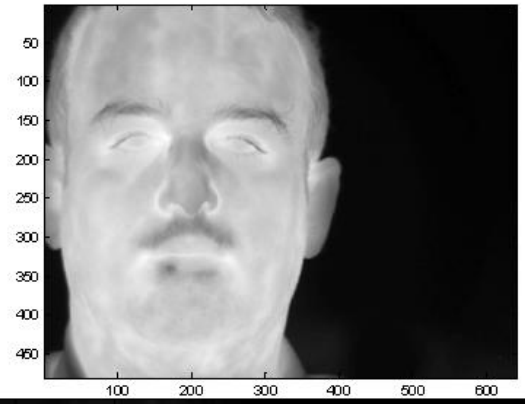
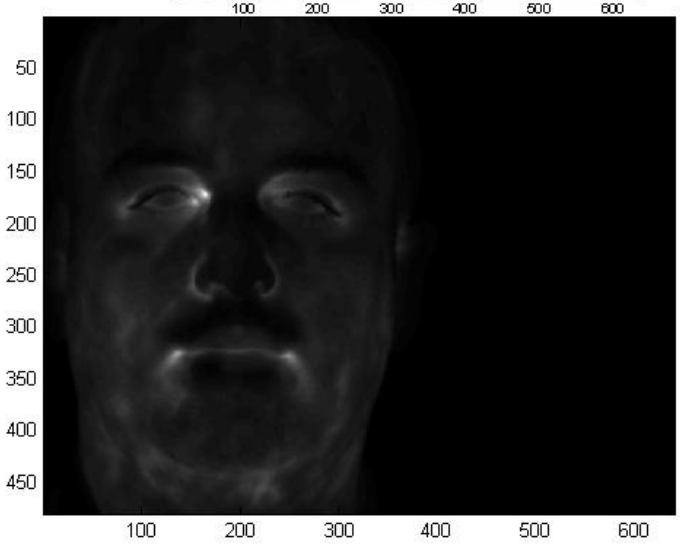
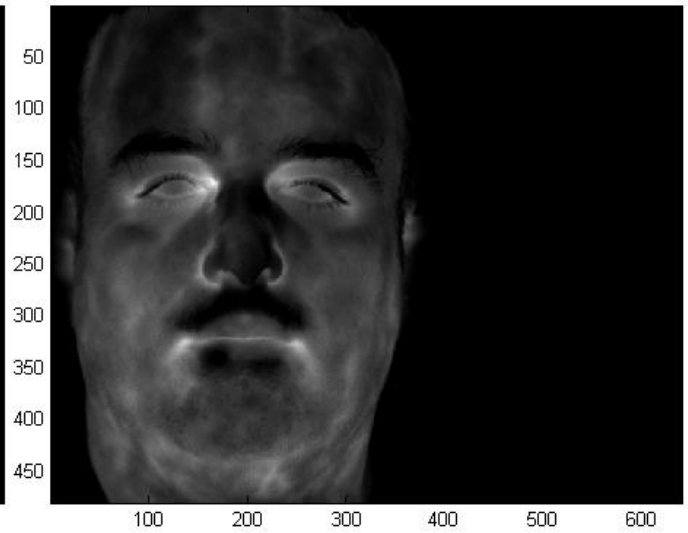
Bio-Heat Models







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Framework

- The framework of the project constitute of two parts
  - Extracting reliable signatures from face data
  - Discovering the most influential and relevant facial features based on statistical models
  - Use pattern recognition for detecting the presence of deception.

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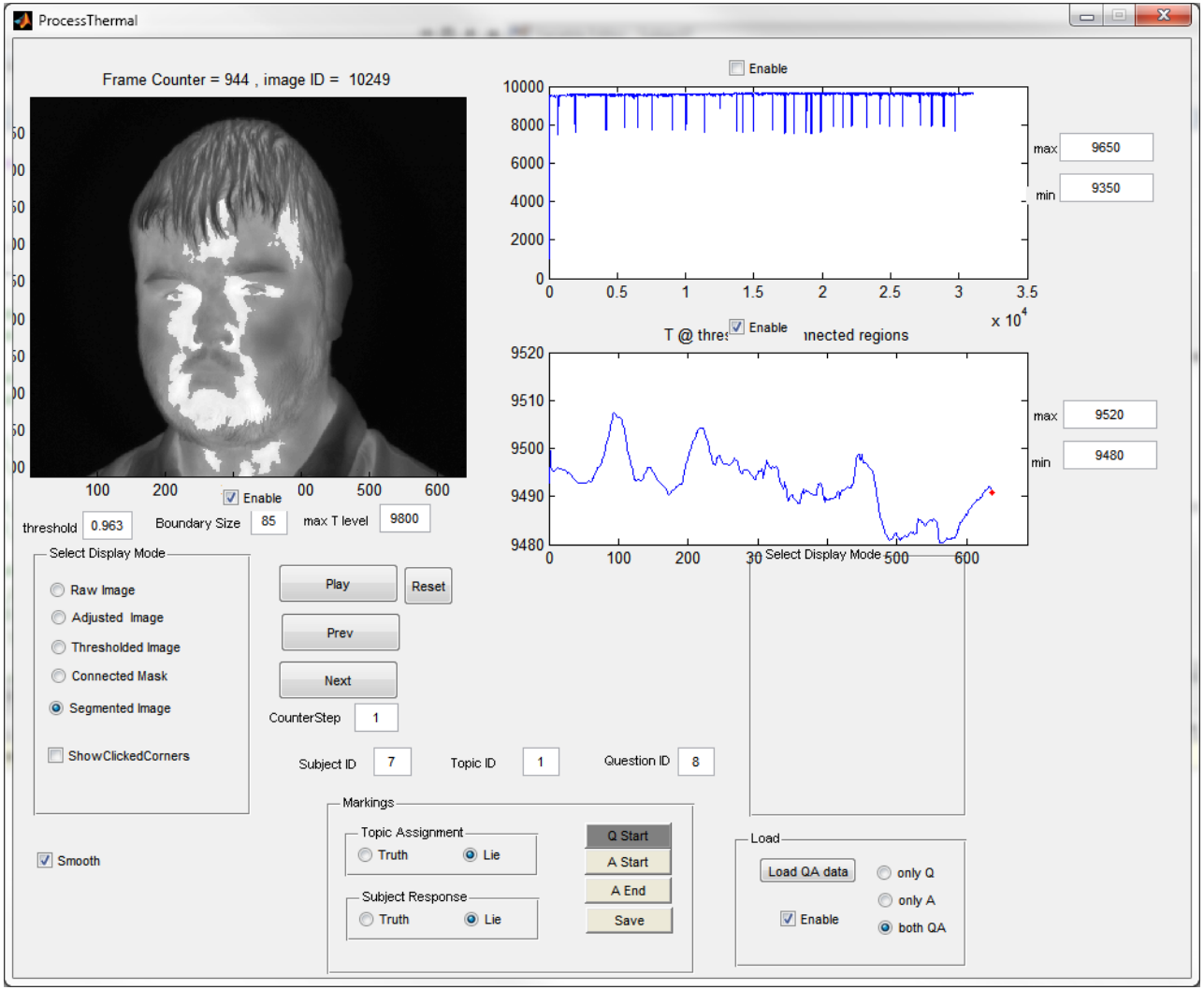

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Experimental Setup

Experimental Setup

- We recruited volunteers who were given a specific story
- On one occasion they were asked to tell the truth when questioned on the story
- On another occasion they were asked to lie on the story

We then analyzed them to extract specific cues both in the visual and thermal domain. These were used to train machine learning algorithms.

Experimental Setup

Current Setup for lie detection

In a given interview, we conduct two separate sessions:

- The first session is a “controlled session” where we determine the baseline of the subject. In this session we ask somewhat “straightforward” questions in which the subject is required to tell the truth.

- The second session is the “interrogation session” in which the subject can choose to lie or to tell the truth.

- We look at the overall score

Typical Session to determine the baseline

- Control Questions

Typical Session to interrogate

- Interrogation Questions

Interview Analysis

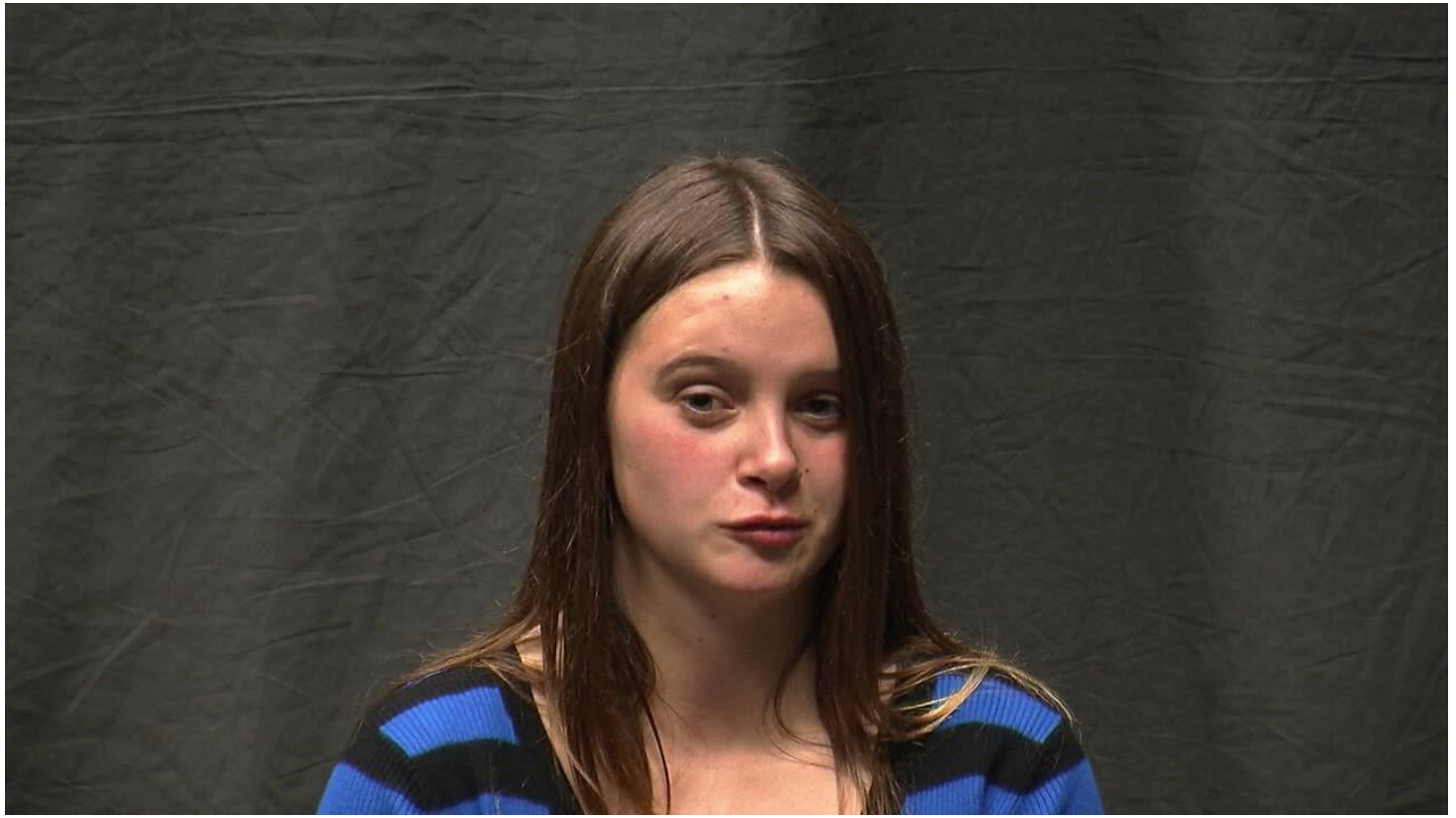
- Visual domain (AU5 Eye lid up)

Interview Analysis

- Visual domain (AU20 Lip Stretch)

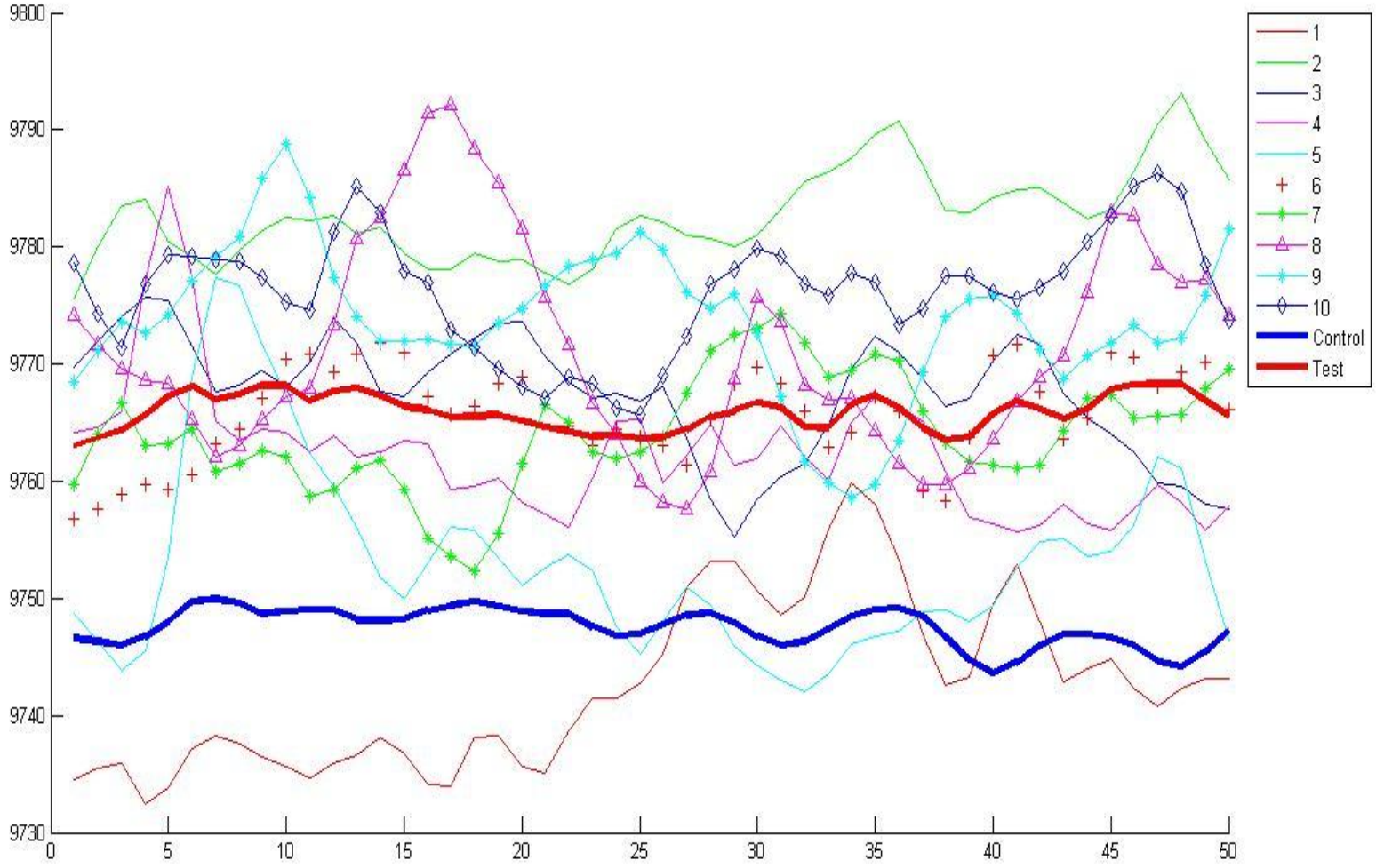
Interview Analysis

- Visual domain (AU19 + AU82)



Interview Analysis

- Visual domain (AU40 Sniff)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Control
Test

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Accuracy

- Based on lab experiments, our system as it is 70% accurate. We can detect 2 out of 3 liars.
- We are planning to carry more experiments and operational trials (including one at an airport)
  - possibility of employing a large number of subjects to prepare significant sample sets
  - this should significantly increase our accuracy rate
  - We hope to get to 90% accuracy rate

Note: BSF week was good as we were able to test the system on number of journalists and news reporters

Applications of this technology

- Mainly interview scenarios, e.g.
  - Interrogations (e.g. Police interrogation)
  - Covert interrogation for counter-terrorism purposes
  - Interviews at immigration/border control points
  - Other general interview situations
  - Any situation where polygraph test is required

Applications of this technology

- Just like any other computer based technology, this technology cannot be 100% fool proof.
- Generally speaking we expect this technology to be utilised as a decision aid.
- Trained officers (e.g. at border control points) are very good in spotting liars.
- We are trying to train a machine to posses such abilities.

Challenges and Future Research

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Further Analysis and Testing

- Further fusing features from both the thermal and visual domains → The multi-modal facial analysis will provide additional information to the current profiling.
  - Facial expression of (both affect and emotion) and micro facial expressions
  - Eye movements, pupil size variations

- Operational Trial
  - Possibility of employing a large number of subjects to prepare significant sample sets.
  - Difference between lab simulations and the real-world

CONCLUDING REMARKS

- The human face is an obvious choice for extracting thermal signatures

→ But

  - faces can be covered,
  - eye glasses is a problem,
  - perhaps some makeup powder can reduce thermal emissions.

- A statistically significant number of subjects is needed to build a reliable classifier
- Noise suppression is required as excessive noise will prevent meaningful physiological interpretation
- A reliable tracking algorithm for facial and periorbital regions of interest is required to compensate for head motion

Other Possible Applications of this Research

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Other Application Areas

Over the past couple years we have gained much understanding of human facial behaviour.

We have developed computer algorithms to analyse the human face both in visual and thermal domain

Other areas we believe this knowledge can be used include

- medical diagnosis. e.g. early detection of dementia. (in the UK alone we have over 800,000 people living with dementia costing the UK economy of £23 billion per year. Current tests are highly invasive. This technology could be an alternative!
- studying/understanding emotional status of people.
- Advanced computer gaming

We believe this is an area where there is strong potential.

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Thank you