Perinasal Indicators of Deceptive Behavior

Malcolm Dcosta, Dvijesh Shastri, Ricardo Vilalta, Judee K. Burgoon and Ioannis Pavlidis
• Introduction
• Methodology
• Experimental Results
• Conclusion
• Deception
  —“To purposely mislead”
Deception
— “To purposely mislead”

Critical cases requiring deception analysis
— In matters concerning national security
  Interrogating suspect terrorists
  Screening people with security clearances
— Criminal justice system
Behavioral Observations

- Voice
- Gestures
- Facial Expressions

Physiological Measurements

- Adrenergic indicators
  - Heart rate
  - Breathing rate
- Cholinergic indicators
  - Electrodermal Activity
Deception Detection Methods

Behavioral Observations
- Voice
- Gestures
- Facial Expressions
  i. More qualitative

Physiological Measurements
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Deception Detection Methods

Behavioral Observations
• Voice
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  i. More qualitative
  ii. Can be controlled to some degree

Physiological Measurements
• Adrenergic indicators
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Behavioal Observations

- Voice
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i. More qualitative
ii. Can be controlled to some degree
iii. Unobtrusive

Physiological Measurements

- Adrenergic indicators
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iii. Contact based methods
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  ➔ Thermal imaging
Perinasal Channel

• Thermal Imaging – Periorbital Channel \[1\]

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• Perinasal Channel
  — Measures sympathetic arousal
  — Perinasal perspiration has been linked to bouts of stress [2]
  — Perinasal response is concomitant to finger response [2]

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• Perinasal Channel
  — Measures sympathetic arousal
  — Perinasal perspiration has been linked to bouts of stress\[2\]
  — Perinasal response is concomitant to finger response\[2\]
  — Deceptive behavior under stakes causes stress
  — Stress manifests through instantaneous perspiration
    - fingers & perinasal region


• Introduction

• **Methodology**

• Experimental Results

• Conclusion
• Collaborative effort
  — Technology group
  — Psychology group
  — Evaluation group
• Collaborative effort
  — Technology group
  — Psychology group
  — Evaluation group

• Design Considerations
  — Realism
  — High stakes
  — Motivation to perform
• Experiment: mock crime scenario – stealing a ring
• Subjects listen to prerecorded instructions
  — Programmed Truthful or Deceptive
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• Subjects listen to prerecorded instructions
  — Programmed Truthful or Deceptive
• They go to a room – chance to commit crime
**Experimental Design**

<table>
<thead>
<tr>
<th>Experiment Briefing</th>
<th>Chance to Steal The Ring</th>
<th>Interview</th>
</tr>
</thead>
</table>

- Reid interview technique[^4]
- Stressful and easy questions (**Relevant and Irrelevant**)

• Goal: Convince interviewer of their innocence

• Subject compensation:
  • If successful in convincing interviewer: $15 + $50
  • If unsuccessful: Only $15
Experimental Setup

• ThermoVision SC6000 MWIR
  — Temperature resolution: 0.025°C
  — Spatial resolution: 640x480 pixels
  — Lens: 100 mm
  — Subject’s distance from camera: 13 ft
  — Recording speed: 25 fps
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Step-1 Signal Extraction


Step-2a: Audio Segmentation
Step-2a: Audio Segmentation

- Each question & answer pair is segmented

- Indexing question-answer pairs
Step-2b: Interview Segmentation

- Grouping of questions and answers based on similarity

<table>
<thead>
<tr>
<th>Easy Questions</th>
<th>IR1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficult Questions</td>
<td>R1</td>
</tr>
<tr>
<td>Easy Questions</td>
<td>IR2</td>
</tr>
<tr>
<td>Difficult Questions</td>
<td>R2</td>
</tr>
<tr>
<td>Difficult Questions</td>
<td>R3</td>
</tr>
<tr>
<td>Difficult Questions</td>
<td>R4</td>
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</table>

![Graph showing raw energy over time](chart.png)
Step-2b: Interview Segmentation

- Grouping of questions and answers based on similarity

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Result</th>
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<tbody>
<tr>
<td>Easy Questions</td>
<td>IR1</td>
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<td>Difficult Questions</td>
<td>R1</td>
</tr>
<tr>
<td>Easy Questions</td>
<td>IR2</td>
</tr>
<tr>
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<td>R2</td>
</tr>
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<td>R3</td>
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Graph showing raw energy over time.
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<td>R1</td>
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<table>
<thead>
<tr>
<th>Easy Questions</th>
<th>IR2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficult Questions</td>
<td>R2</td>
</tr>
<tr>
<td>Difficult Questions</td>
<td>R3</td>
</tr>
<tr>
<td>Difficult Questions</td>
<td>R4</td>
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Step-2c: Signal Segmentation

- Indexing the perspiration signal via the audio segments

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Six Segments
Step-2c: Signal Segmentation

• Indexing the perspiration signal via the audio segments

Six Segments

- IR 1
- R1
- IR 2
- R2
- R3
- R4
• Feature \(\rightarrow\) rate of perspiration per segment
• Feature $\rightarrow$ rate of perspiration per segment
Feature Extraction

- Feature → rate of perspiration per segment

Glands secrete in a pulsate manner\textsuperscript{[5]}
- Use wavelet analysis to compute rate

Feature Extraction

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### Features

<table>
<thead>
<tr>
<th>Subject</th>
<th>IR1</th>
<th>R1</th>
<th>IR2</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>D001</td>
<td>0.03385</td>
<td>0.09149</td>
<td>0.05936</td>
<td>0.04836</td>
<td>0.03627</td>
<td>0.07228</td>
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<tr>
<td>D004</td>
<td></td>
<td></td>
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<td></td>
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<td>...</td>
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Hypothesis

• All participants experience some stress during the interview
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Hypothesis

• All participants experience some stress during the interview

- Truthful Subject
  - Irrelevant Questions
  - Relevant Questions

- Deceptive Subject
  - Irrelevant Questions
  - Relevant Questions

• Deceptive subjects experience higher stress during the relevant questions
• Test the differential rate of perspiration between relevant and irrelevant question segments

\[ f_R - f_{IR} \rightarrow \begin{cases} 
> 0 & \text{subject}(i) \text{ is D} \\
\leq 0 & \text{subject}(i) \text{ is T},
\end{cases} \]

where,

\[ f_R = avg(f_{R1}(i), f_{R2}(i), f_{R3}(i)), \]
\[ f_{IR} = avg(f_{IR1}(i), f_{IR2}(i)), \]
Machine Learning Approach

• Classifiers

— Decision Tree
— AdaBoost using Decision Stump
— AdaBoost using Naïve Bayes
— Multilayer Perceptron
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• Total of 40 subjects used in analysis (17 M, 23 F)

• Training set (25 subjects)
  — Leave-one-out cross validation

• Test set (15 subjects – Blind prediction)
Classification Success Rates

Training Set

- Truthful
- Deceptive

<table>
<thead>
<tr>
<th>Classifier</th>
<th>Percentage (%)</th>
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</thead>
<tbody>
<tr>
<td>Threshold Classifier</td>
<td>90</td>
</tr>
<tr>
<td>Multilayered Perceptron</td>
<td>70</td>
</tr>
<tr>
<td>Decision Stump</td>
<td>90</td>
</tr>
<tr>
<td>Decision Tree</td>
<td>80</td>
</tr>
<tr>
<td>Naïve Bayes</td>
<td>90</td>
</tr>
</tbody>
</table>
Classification Success Rates

Test Set

- Threshold Classifier
- Multilayered Perceptron
- Decision Stump
- Decision Tree
- Naïve Bayes

Truthful vs. Deceptive

Percentage (a)
Classification Success Rates

<table>
<thead>
<tr>
<th>Classifier</th>
<th>Training Set</th>
<th>Test Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold Classifier</td>
<td>95%</td>
<td>85%</td>
</tr>
<tr>
<td>Multilayered Perceptron</td>
<td>90%</td>
<td>80%</td>
</tr>
<tr>
<td>Decision Stump</td>
<td>85%</td>
<td>75%</td>
</tr>
<tr>
<td>Decision Tree</td>
<td>90%</td>
<td>80%</td>
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- **Experimental Results**
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• Perinasal perspiratory rate tracks deceptive behavior within an appropriate interrogation context
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• Good psychology theory +
  Good experimental practice +
  Good physiology theory +
  Good methods
• Perinasal perspiratory rate tracks deceptive behavior within an appropriate interrogation context

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• Performance scales up from training to test set
• This work was supported by the National Center for Credibility Assessment