Adventures in Building Emotion Intelligence Technologies

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Professor, MIT Media Lab
Faculty Chair, MIT Mind+Hand+Heart
Co-founder and Chairman, Empatica, Inc.
Co-founder, Affectiva Inc.

Media Lab Affective Computing
Affective computing is computing that relates to, arises from, or deliberately influences emotion.
Intelligent interaction?
Intelligent interaction?
Intelligent interaction?
Intelligent interaction?

These should stop looking happy
``Singing cheerful songs to a person with a heavy heart is like taking someone's coat in cold weather or pouring vinegar in a wound.  Proverbs 25:20  New Living Translation

Intelligent interaction?

These should stop looking happy
“The true smile of delight?”
We didn’t tell him we used “impossible” captchas
We didn’t tell him we used “impossible” captchas
90% of people showed this smile during frustration.
Machine learning to classify delight vs. frustration smiles


Accuracy (F1)

Best Machine 92%

Human  Machine

92%

M-NB

Human

M-SVM

M-DSVM

M-HMM

M-HCRF

Delight

Frustration
Opt in online with your webcam

Deployment actually improved the science!

Dan McDuff, MIT PhD 2014
Crowdsourcing facial affect and prediction analytics:

• Won best student paper award Face & Gesture
• The only paper at ESOMAR nominated for all three prizes:
  “Best methodology paper”
  “Best case history”
  “Best overall paper”

http://affect.media.mit.edu/publications.php
Interactive real-time facial emotion recognition

- 90% accurate on 24 expressions
- 75 countries
- 50 B emotion data points measured
- 1400 brands
- Used by 1/3 of Fortune Global 100
- HCI, Gaming, Robots, Medical

Demo App
AffdexMe
FREE at: 

@affectiva

Download on the Apple App Store
Real-Time Emotion SDK

Makes it easy to add facial emotion sensing to adapt to human emotion in real time.

For gaming, robotics, automotive, retail, advertising, education, healthcare and mobile devices.

Get affectiva.com/sdk FREE!
Electrodermal Activity (EDA) Sensors
(old terminology: “galvanic skin response”)

Traditional: Biopac, Thought Technology
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MIT Media Lab Innovations
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MIT Media Lab Innovations

Empatica Embrace and E4
E4 for research:
- Physical activity
- Temperature
- 2-color PPG (BVP)
- Skin conductance

Autonomic stress: Sympathetic & Parasympathetic
Empatica E4 sensor data

Real Time Streaming

Electrodermal Activity

Blood Volume Pulse

Temperature: 33.71°C
Sympathetic division
Stimulation: “fight or flight”

AUTONOMIC NERVOUS SYSTEM

Parasympathetic division
Inhibitory: “rest and digest”

(Not shown: Enteric division)

Used with permission from R. Sapolsky
Your phone records YOUR subtle motions even when you’re “NOT MOVING”
Physiology Monitoring from Peripheral Smartphone Motions

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Physiology Monitoring from Peripheral Smartphone Motions

<table>
<thead>
<tr>
<th></th>
<th>Heart Rate (Beats/min)</th>
<th>Breaths/min</th>
<th>Avg Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hernandez J., McDuff D., Picard R. W.</td>
<td>3.37</td>
<td>2.16</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>7.90</td>
<td>2.26</td>
<td>2.05</td>
</tr>
<tr>
<td></td>
<td>2.38</td>
<td>2.05</td>
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</tr>
</tbody>
</table>

Heart rate and breathing rate from smartphone motions

Sympathetic division
Stimulation: “fight or flight”

Parasympathetic division
Inhibitory: “rest and digest”

AUTONOMIC NERVOUS SYSTEM
(Not shown: Enteric division)
MIT Student, 7 days, 24 hours/day

Electrodermal Activity, μS

Day 7
- Lab
- TV
- Sleep
- Relax
- Lab

Day 6
- Exam
- Study
- Sleep
- Exam
- Class

Day 5
- Study
- Sleep
- Class

Day 4
- Lab
- TV
- Study
- Sleep
- Class

Day 3
- Lab
- Chores
- Social
- Sleep
- Relax
- Lab

Day 2
- Lab
- Homework
- Sleep
- Class

Day 1
- Lab
- Homework
- Sleep
- Class

Time (hr)
MIT Student, 7 days, 24 hours/day

Largest peaks of “arousal” are usually during Non-REM sleep
Discriminating high/low learning after sleep: EDA (wrist) is more accurate than EEG (scalp).

N=24 healthy adults, 72 nights of sleep. Classifying highest vs. lowest 20% of VDT Performance, Sano & Picard, Body Sensor Networks, Cambridge MA 2013
Measuring electrodermal activity (EDA): Peak = meltdown
“Can I borrow a sensor to see what is causing stress for my little brother?”
Seizures labeled from EEG
SUDEP
Sudden Unexpected Death in Epilepsy

YPLL (Thousands)

<table>
<thead>
<tr>
<th>Disease</th>
<th>YPLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke</td>
<td>189</td>
</tr>
<tr>
<td>SUDEP</td>
<td>101</td>
</tr>
<tr>
<td>ALS</td>
<td>57</td>
</tr>
<tr>
<td>MS</td>
<td>46</td>
</tr>
<tr>
<td>Alz</td>
<td>30</td>
</tr>
<tr>
<td>PD</td>
<td>18</td>
</tr>
<tr>
<td>Men/Enc</td>
<td>15</td>
</tr>
</tbody>
</table>
Post-ictal generalized EEG suppression (PGES) was found in 100% of monitored cases of SUDEP. *MORTEMUS* study by Ryvlin et al., Lancet Neurology 2013.
PGES = Post-ictal Generalized EEG Suppression

The longer the brain waves are suppressed, the bigger the signal on the wrist!
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PGES = Post-ictal Generalized EEG Suppression

Autonomic changes with seizures correlate with postictal EEG suppression

M.-Z. Poh, PhD, T. Loddenkemper, MD, C. Reinsberger, MD, PhD, N.C. Swenson, S. Goyal, J.R. Madsen, MD and R.W. Picard, ScD
Stimulating left amygdala gives largest left-palm EDA

Stimulating right amygdala gives largest right-palm EDA

Seizures are like little electrical fires in your brain.

SUDEP = Sudden unexpected death in epilepsy, every 7-9 minutes, more deaths then house fires.
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An alert might prevent seizure deaths
Physical Activity
Sleep/Wake
Time
Temperature
Seizure detection (USA: in clinical trial)
Alerts
Water-resistant
Stress (coming)
API (coming)
Email from a beta user:

The Embrace is impressive! We got another alert this morning, ran to her room and she was face down with a seizure/not breathing!

We repositioned her and she is now pink and sleeping.
Deep brain/neural activity -> signals on wrist?

*Embryo has three tissue types:*

<table>
<thead>
<tr>
<th>Ectoderm</th>
<th>Skin and neural</th>
</tr>
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<tbody>
<tr>
<td>Endoderm</td>
<td>Digestive and respiratory track</td>
</tr>
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<td>Mesoderm</td>
<td>Muscle and bone</td>
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What my former boss always asked for....
Growing challenge: the future of mood
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Major Depressive Disorder is the leading cause of disability in the U.S. for ages 15-44.
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Suicide is higher in developing countries and growing worldwide (WHO, 2012, 2014)
- By 2020, 1 suicide will happen every 20 seconds
- By 2030, disability and lives lost from depression will be greater than from cancer, accidents, war, and stroke.
Ambulatory Measurement

- Physiology
- Behavior
- Social Interaction
- Environment
- Experience Sampling

Lab Measurement

- Standardized questionnaires
- Saliva (Melatonin)
- Cognitive and Affective stress tasks
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Future: Forecast when you are likely to get sick or depressed

Long-term monitoring & analysis

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Multi-task Learning to Predict Stress, Health, & Happiness

- Each person’s machine learning model includes insights from self and from others

- **Goal:** Predict your physical health, stress, and happiness from your wearable + smartphone data for TOMORROW NIGHT based on your data through today.

- **Accuracy:** 82-87%

Multi-tasked deep neural network architecture

Major stressors

Wellbeing

positive

negative

Major stressors

Resilient

Vulnerable

time
Wellbeing

Idea: PREVENT 80% of Depression
Hard enough to earn a PhD
DO NO EVIL?
Hard enough to earn a PhD

Do little good

Super hard