From Wearables to Unwearables: Edge Computing for Health

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The rise of wearables

Polar Sport Tester PE 1982

The Garmin Forerunner 201

2003

Wearables for Mental Health

Transfer entropy and network dynamics between heart rate and locomotor activity are altered in schizophrenia

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Physiol Meas. 2018 Oct 30;39(11):115001. doi: 10.1088/1361-6579/aae1ed.

Multiscale network dynamics between heart rate and locomotor activity are altered in schizophrenia.

Reinertsen E[1], Shashikumar SP, Shah AJ, Nemati S, Clifford GD.

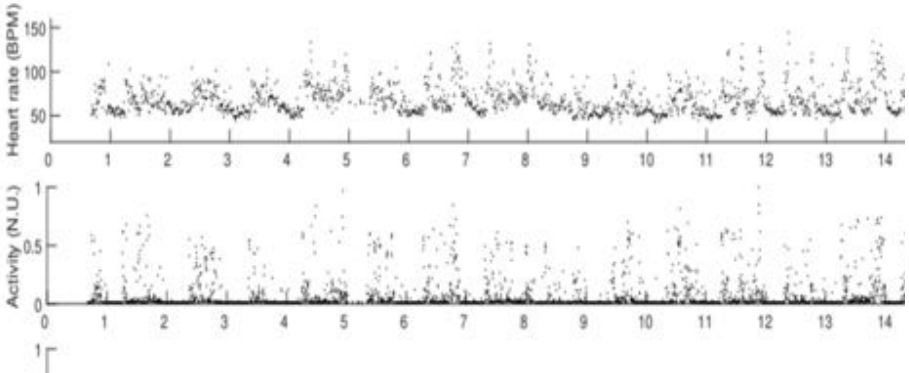
Author information

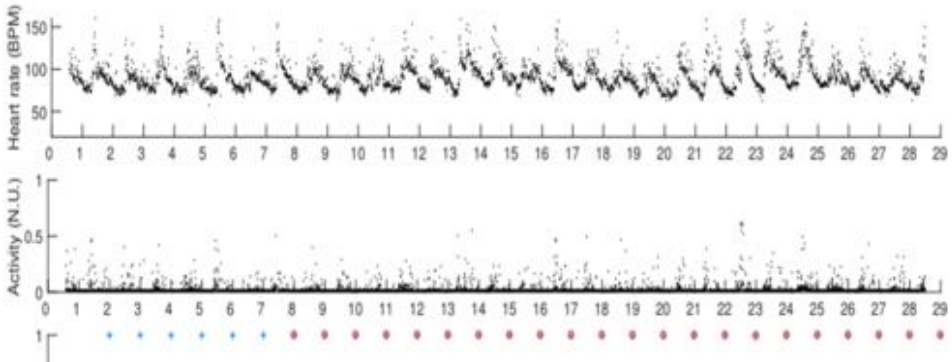
Abstract

OBJECTIVE: Changes in heart rate (HR) and locomotor activity reflect changes in autonomic physiology, behavior, and mood. These systems may involve interrelated neural circuits that are altered in psychiatric illness, yet their interactions are poorly understood. We hypothesized interactions between HR and locomotor activity could be used to discriminate patients with schizophrenia from controls, and would be less able to discriminate non-psychiatric patients from controls.

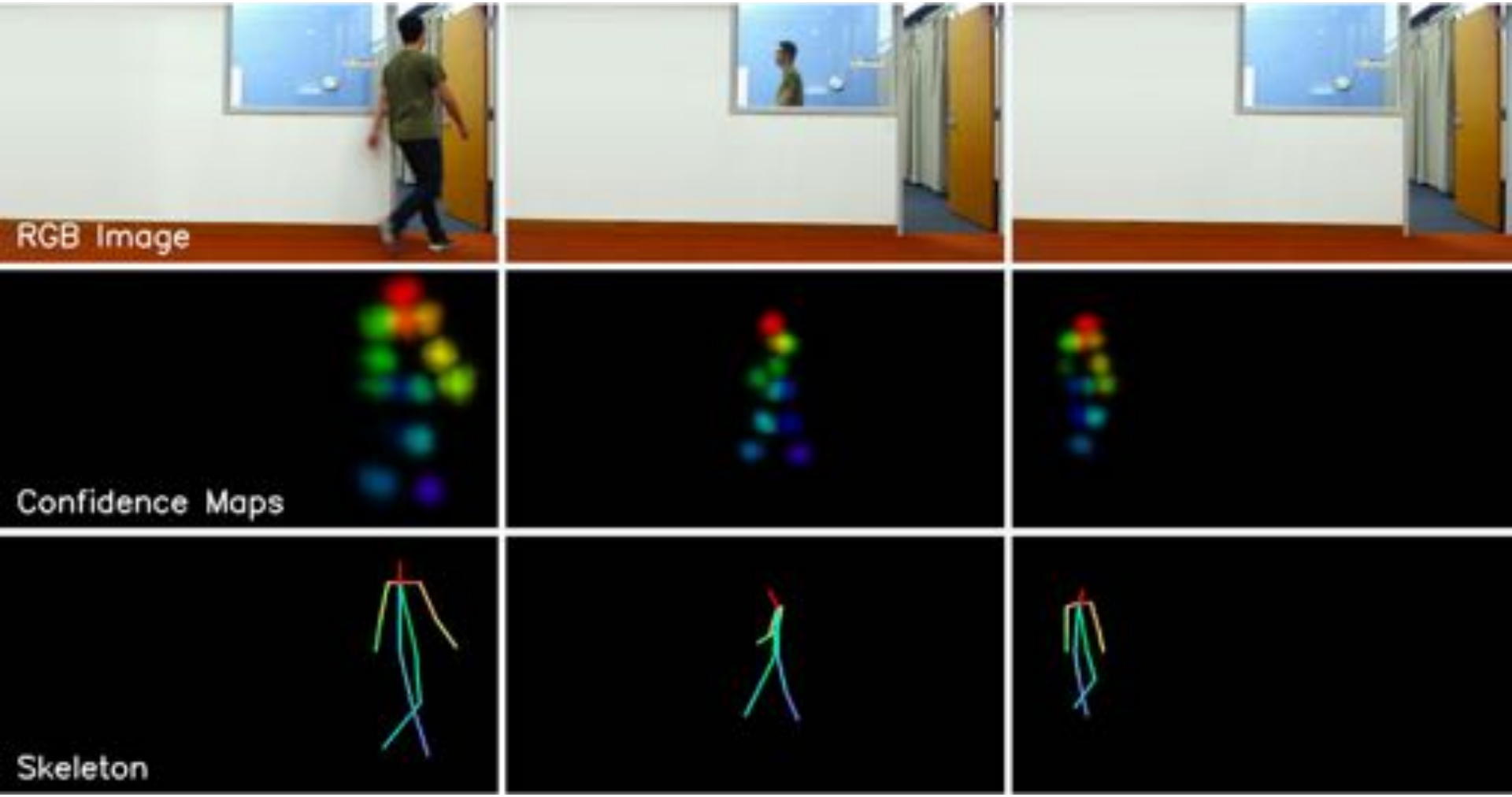
APPROACH: HR and locomotor activity were recorded via wearable patches in 16 patients with schizophrenia and 19 healthy controls. Measures of signal complexity and interactions were calculated over multiple time scales, including sample entropy, mutual information, and transfer entropy. A support vector machine was trained on these features to discriminate patients from controls. Additionally, time series were converted into a network with nodes comprised of HR and locomotor activity states, and edges representing state transitions. Graph properties were used as features. Leave-one-out cross validation was performed. To compare against non-psychiatric illness, the same approach was repeated in 41 patients with atrial fibrillation (AFib) and 53 controls.

MAIN RESULTS: Network features enabled perfect discrimination of schizophrenia patients from controls with an areas under the receiver operating characteristic curve (AUC) of 1.00 for training and test data. Other bivariate measures of interaction achieved lower AUCs (train 0.98, test 0.96), and univariate measures of complexity achieved the lowest performance. Conversely, interaction features did not improve discrimination of AFib patients from controls beyond univariate approaches.



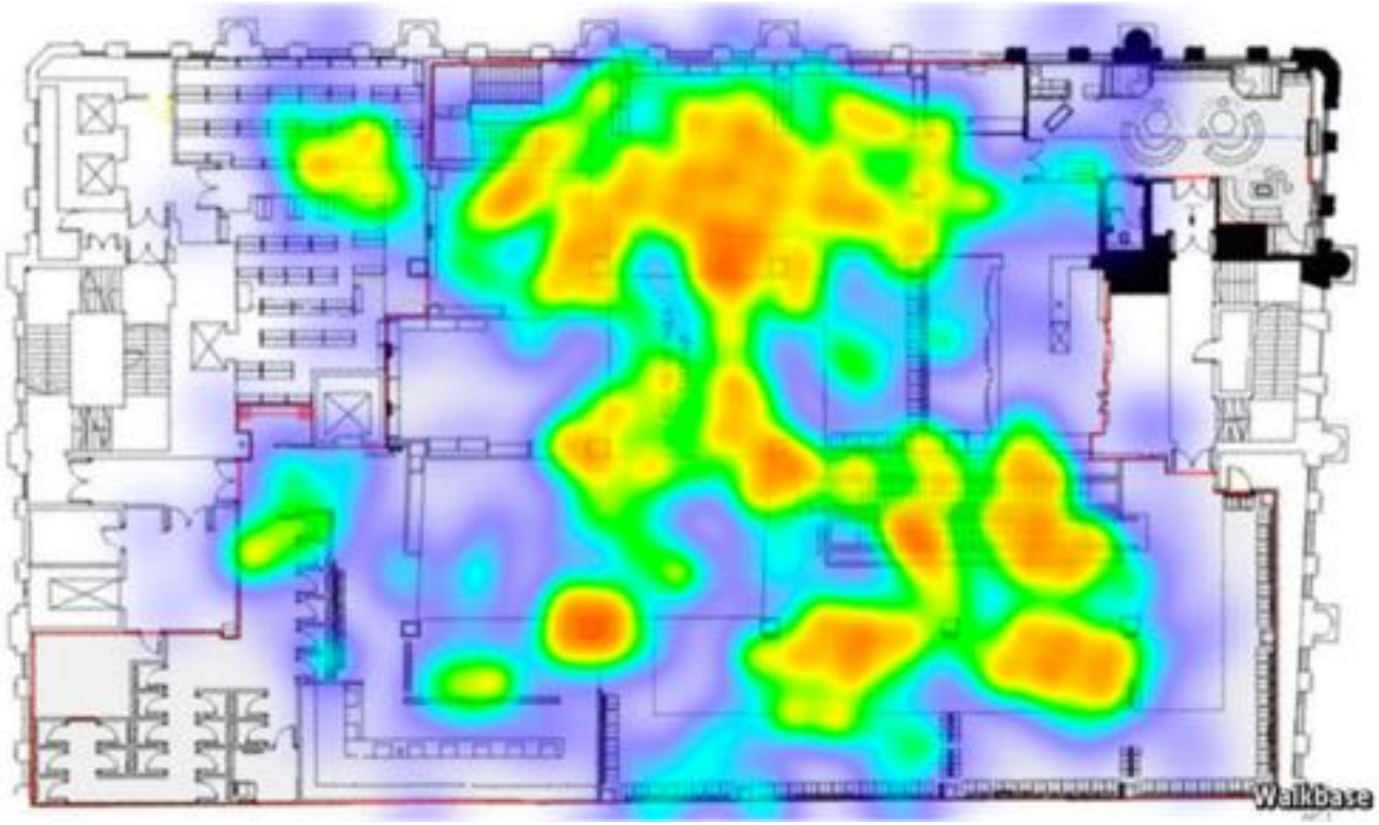


Unwearables

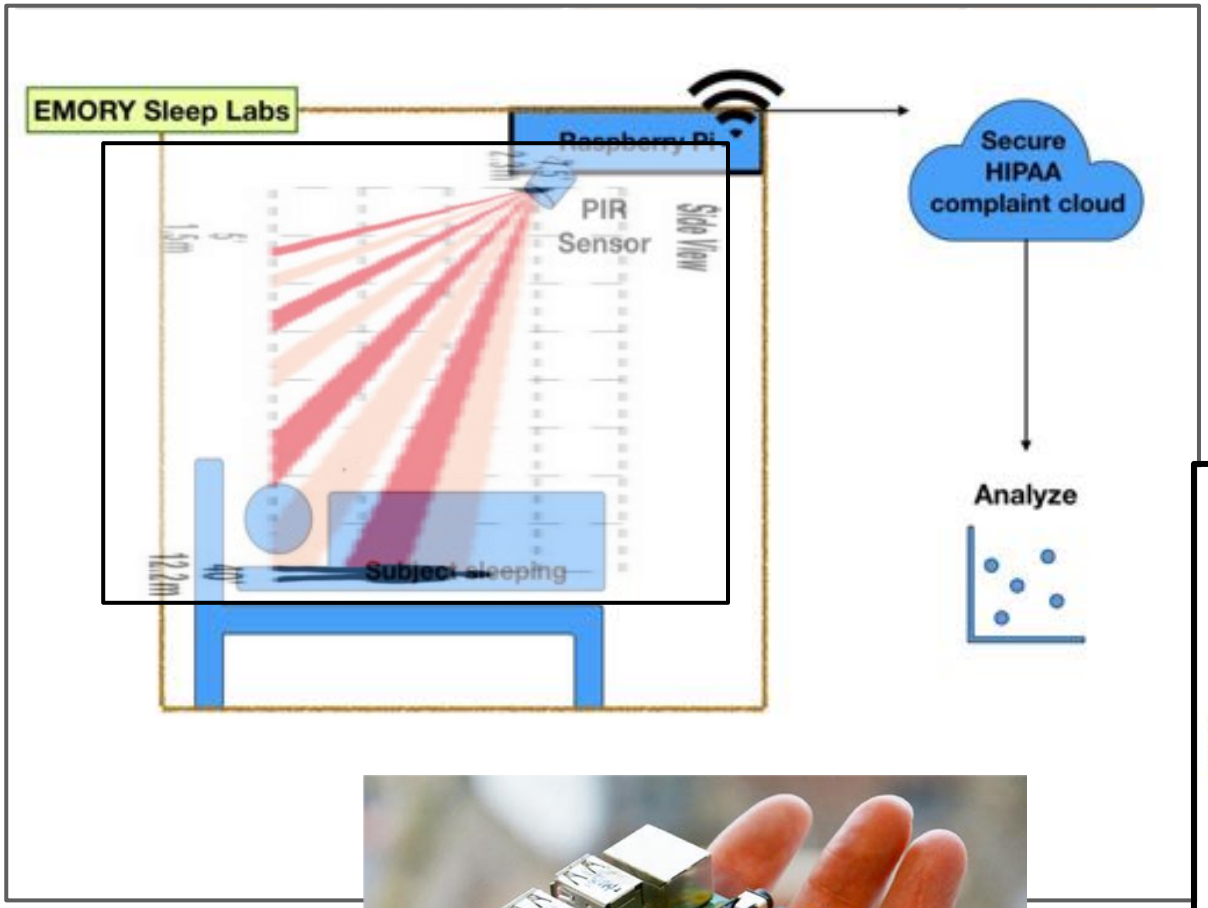


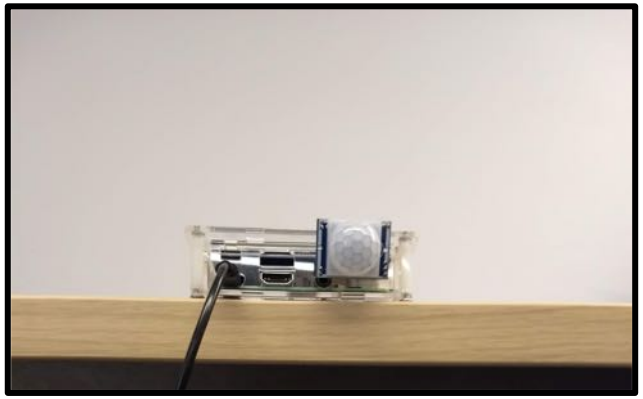
Mingmin Zhao, Tianhong Li, Mohammad Abu Alsheikh, Yonglong Tian, Hang Zhao, Antonio Torralba, Dina Katabi
Through-Wall Human Pose Estimation Using Radio Signals, Computer Vision and Pattern Recognition (CVPR), 2018

Unwearables: Random Walks?

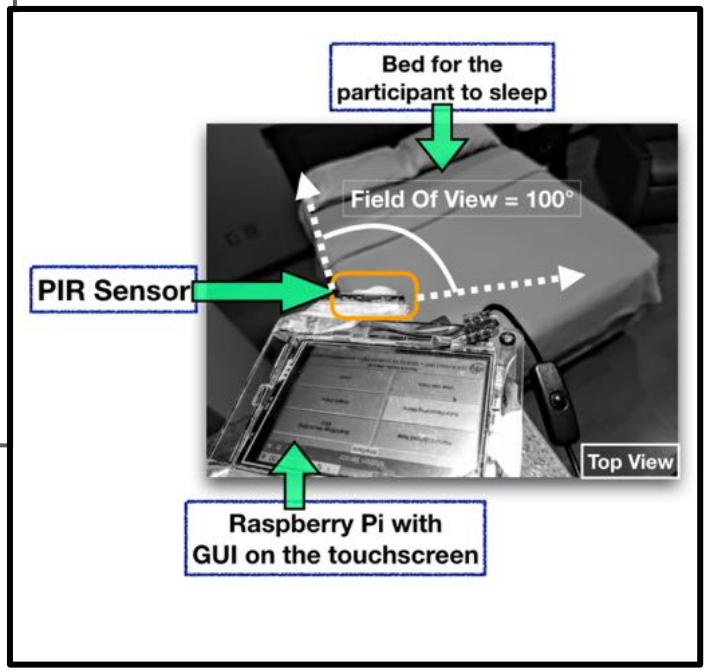


A low cost hack





View of the Raspberry Pi system from the bed

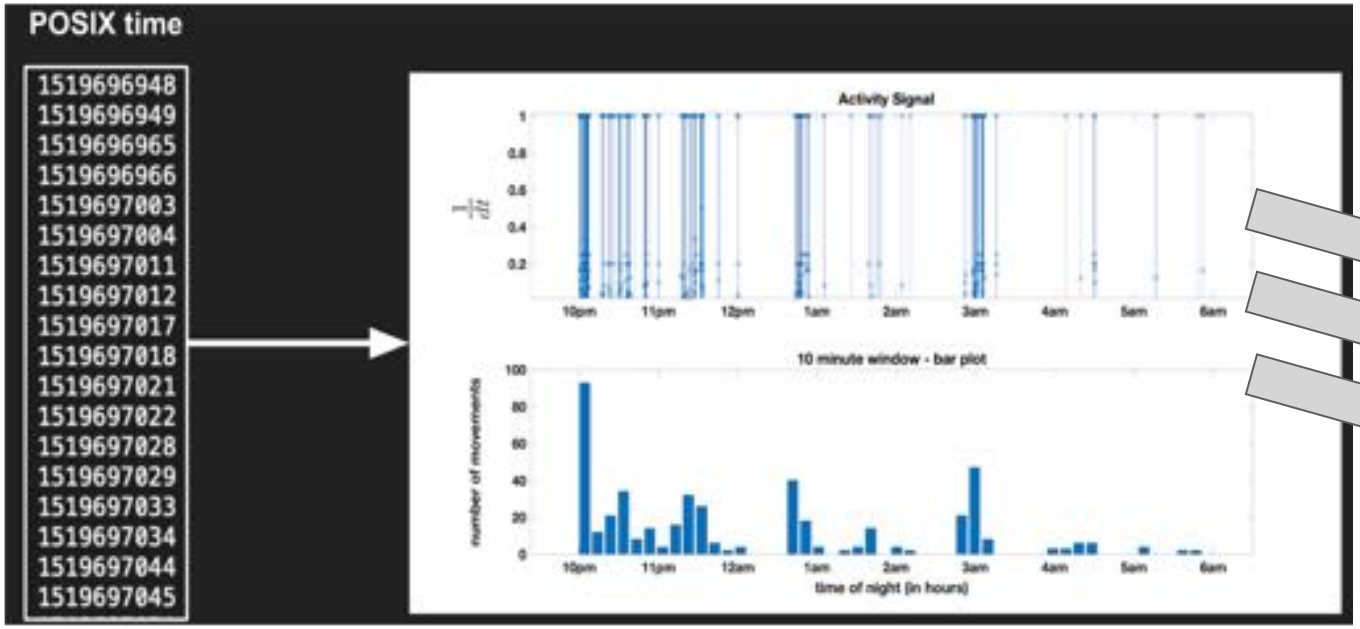


Diagnosing sleep apnea

- **32** war veterans diagnosed with *depression*, *PTSD* and *no diagnosed psychiatric issues*.

- **11/32** participants had *Periodic Leg Movement Disorder*.

Movement Signal from PIR Sensor -> Features -> Machine Learning -> Diagnosis



Entropy (Randomness)

Statistics (Energy,)

Covariates? E.g. PLMI

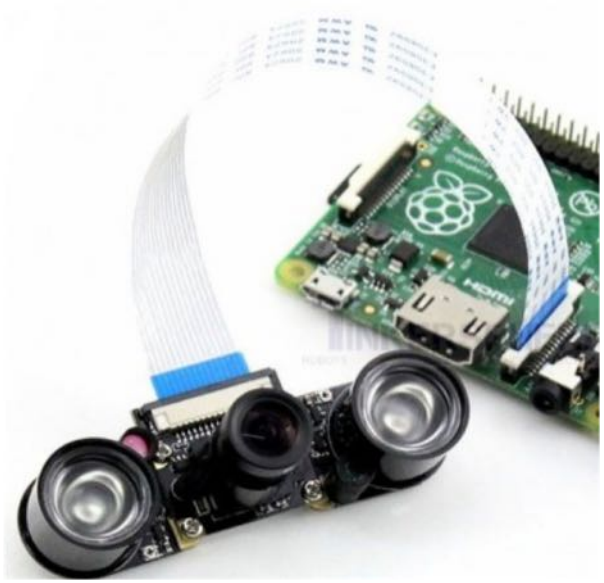
> 84% Accuracy in detecting sleep apnea

…. just from the PIR movement sequences!

Motion Detection using Low Cost Video

- Raspberry Pi mini computer

  + 5MP IR Camera



Algorithm

Input

Pre-Processing

Detecting motion between different frames

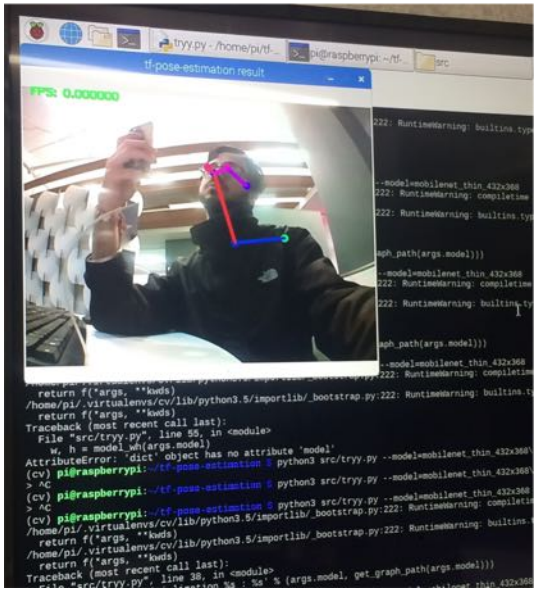
Detect contours

Detect Human Activity

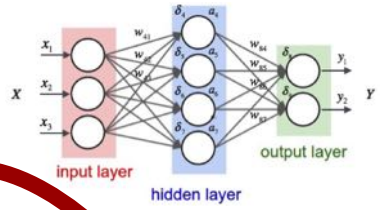
Characterize their movement

Complex Activity Tracking

Authors Gines Hidalgo(left) and Hanbyul Joo(right) in front of the CMU Panoptic Studio



Emotion Detection From Video



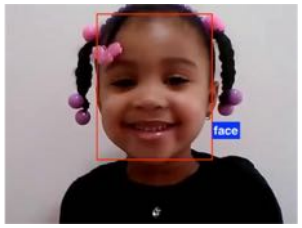
DL model trained with public data

video of a patient

separate into frames

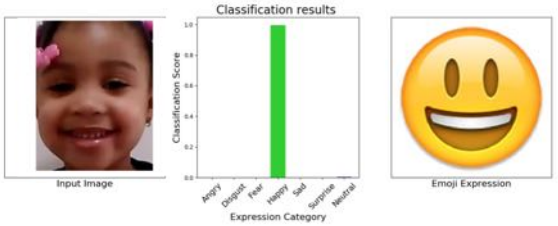
frame by frame

face detection

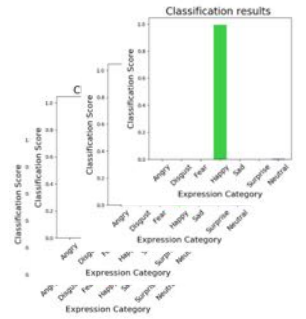


faces

emotion recognition



Emotion fluctuations in one video (time series)



P(surprise)
P(sad)
P(neutral)
P(happy)
P(fear)
P(disgust)
P(angry)

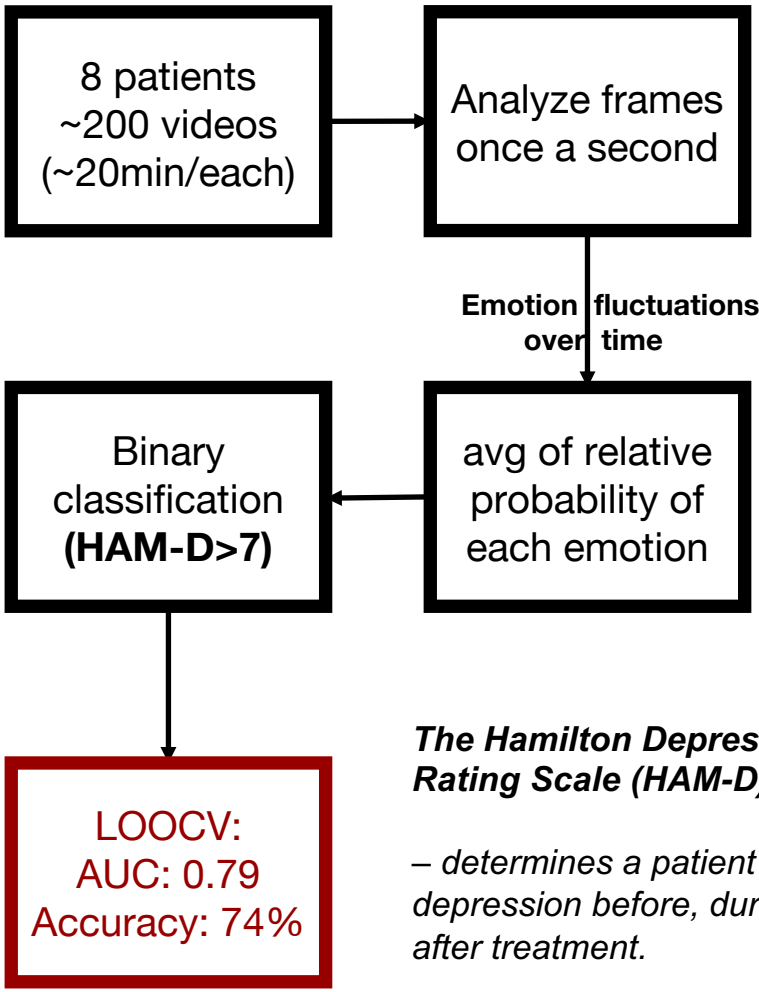
Classifier applied to time series

Result

small model trained with private data

Emotion Detection Demo (Actor)

Application to Severe Depression



The Hamilton Depression Rating Scale (HAM-D)

– determines a patient's level of depression before, during, and after treatment.

Hamilton Rating Scale for Depression (17-items)

Instructions: For each item select the "cue" which best characterizes the patient during the past week.

1. **Depressed Mood**
(sadness, hopeless, helpless, worthless)
0 Absent
1 These feeling states indicated only on questioning
2 These feeling states spontaneously reported verbally
3 Communicates feeling states nonverbally, i.e., through facial expression, posture, voice and tendency to weep
4 Patient reports VIRTUALLY ONLY these feeling states in his spontaneous verbal and nonverbal communication

2. **Feelings of Guilt**
0 Absent
1 Self-reproach, feels he has let people down
2 Ideas of guilt or rumination over past errors or sinful deeds
3 Present illness is a punishment. Delusions of guilt
4 Hears accusatory or denunciatory voices and/or experiences threatening visual hallucinations

3. **Suicide**
0 Absent
1 Feels life is not worth living
2 Wishes he were dead or any thoughts of possible death to self
3 Suicide ideas or gesture
4 Attempts at suicide (any serious attempt rates 4)

4. **Insomnia - Early**
0 No difficulty falling asleep
1 Complains of occasional difficulty falling asleep i.e., more than ½ hour
2 Complains of nightly difficulty falling asleep

5. **Insomnia - Middle**
0 No difficulty
1 Patient complains of being restless and disturbed during the night
2 Waking during the night – any getting out of bed rates 2 (except for purposes of voiding)

6. **Insomnia - Late**
0 No difficulty
1 Waking in early hours of the morning but goes back to sleep
2 Unable to fall asleep again if gets out of bed

7. **Work and Activities**
0 No difficulty
1 Thoughts and feelings of incapacity, fatigue or weakness related to activities; work or hobbies
2 Loss of interest in activity; hobbies or work – either directly reported by patient, or indirect in listlessness, indecision and vacillation (feels he has to push self to work or activities)
3 Decrease in actual time spent in activities or decrease in productivity. In hospital, rate 3 if patient does not spend at least three hours a day in activities (hospital job or hobbies) exclusive of ward chores.
4 Stopped working because of present illness. In hospital, rate 4 if patient engages in no activities except ward chores, or if patient fails to perform ward chores unassisted.

8. **Retardation**
(slowness of thought and speech; impaired ability to concentrate; decreased motor activity)
0 Normal speech and thought
1 Slight retardation at interview
2 Obvious retardation at interview
3 Interview difficult
4 Complete stupor

9. **Agitation**
0 None
1 "Playing with" hand, hair, etc.
2 Hand-wringing, nail-biting, biting of lips

10. **Anxiety - Psychic**
0 No difficulty
1 Subjective tension and irritability
2 Worrying about minor matters
3 Apprehensive attitude apparent in face or speech
4 Fears expressed without questioning

11. **Anxiety - Somatic**
0 Absent — Physiological concomitants of anxiety such as:
1 Mild — Gastrointestinal - dry mouth, wind, indigestion,
2 Moderate — diarrhea, cramps, belching
3 Severe — Cardiovascular – palpitations, headaches
4 Incapacitating — Respiratory - hyperventilation, sighing
Urinary frequency
Sweating

12. **Somatic Symptoms - Gastrointestinal**
0 None
1 Loss of appetite but eating without staff encouragement. Heavy feelings in abdomen.
2 Difficulty eating without staff urging. Requests or requires laxatives or medications for bowels or medication for G.I. symptoms.

13. **Somatic Symptoms - General**
0 None
1 Heaviness in limbs, back or head, backaches, headache, muscle aches, loss of energy and fatigability
2 Any clear-cut symptom rates 2

14. **Genital Symptoms**
0 Absent 0 Not ascertained
1 Mild — Symptoms such as: loss of libido,
2 Severe — menstrual disturbances

15. **Hypochondriasis**
0 Not present
1 Self-absorption (bodily)
2 Preoccupation with health
3 Frequent complaints, requests for help, etc.
4 Hypochondriacal delusions

16. **Loss of Weight**
A. When Rating by History:
0 No weight loss
1 Probable weight loss associated with present illness
2 Definite (according to patient) weight loss

B. On Weekly Ratings by Ward Psychiatrist, When Actual Changes are Measured:
0 Less than 1 lb. weight loss in week
1 Greater than 1 lb. weight loss in week
2 Greater than 2 lb. weight loss in week

17. **Insight**
0 Acknowledges being depressed and ill
1 Acknowledges illness but attributes cause to bad food, climate, overwork, virus, need for rest, etc.
2 Denies being ill at all

Total Score:

What next?