Unobtrusive assessment of emotional states and depression using smartphone technology

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***Abstract*— The study of emotions is increasingly important in psychology. An emotional episode is characterized by changes in five subsystems: information processing (appraisal), support (bodily symptoms), executive (action tendencies), action (facial and vocal expression) and monitoring (emotional experience). A comprehensive measure of an emotion, combining the states of all subsystems involved, has never been put into practice. For the assessment of psychopathological states, such as depression, in particular in older age groups, there is a further need for unobtrusive assessment, with technological aid to help identify early signs of illness, through indirect emotional recognition. We aim to develop smartphone technology with incorporated sensors that can unobtrusively monitor, record and process: a) a combination of several markers; b) individual baseline information, to track future changes.**

***Keywords*— Unobtrusive assessment; Smartphone technology; Emotional recognition.**

I. Introduction

An emotional episode is characterized by the respective states of the five subsystems: information processing (appraisal), support (bodily symptoms), executive (action tendencies), action (facial and vocal expression) and monitoring (emotional experience) [1], Given this component nature of emotion, it is the belief of many theorists that only combined measurement, via the assessment of all component changes involved, can provide a comprehensive measure of an emotion. However, such a comprehensive measurement has never been fully developed. Most measures used are partial and focus on aspects of emotional response that demand an active participation of the individuals under assessment. Major advances in emotional measurement in recent years have ranged from aspects such as appraisal [2], brain mechanisms [3], physiological response patterns [4], and expressive behaviour [5]. However, all of these advances have taken place with obtrusive, lab-based measurement. In contrast, the emergent breakthrough is in unobtrusive, pervasive measurements. This is the field in which we are investing. We aim to develop behavioural, nonintrusive measurement of emotions via mobile applications. We are also interested in the application of those measures to assess negative emotions flagging symptoms of depression in older people. This is a major health problem, highly prevalent, and currently underdiagnosed in older people. Traditional categorical assessment and "paper and pencil" tests are not fully appropriate for this population, as depressed older people typically do not display the overt depressed mood central to a diagnosis of major depression [6]. According to the literature, these measures should combine several markers to detect emotional responses, such as physiological symptoms, motor expression and action tendencies, as each individual component in isolation does not provide sufficient relevant information [7]. In the case of depression assessment, an individual baseline should be determined, to be used in order to track subsequent changes. Some existing technological devices include in-home sensors and cloud software designed to detect signs such as the user's pattern of activities and motion around the house [8,7], sleep quality, body weight, and

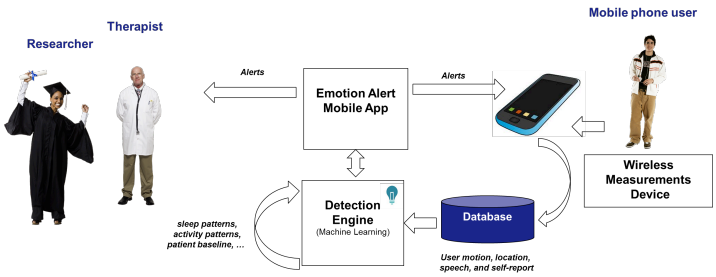
speech prosody [8], and obtrusive measures such as heart rate based on a chest-worn monitoring device [9].

Some existing technological devices should be useful for this purpose. As an example, existing technology incorporated in smartphones allows the detection of variations in speech, such as speaking rate or volume; frequency of speech, statistics of intensity, speech rate and duration. Also, interaction with touch screens, e.g., finger movements, pressure intensity and speed could be used to measure emotion or moods.

II. Expected Outcome

We expect that the use off-the-shelf smartphone technology with incorporated sensors will provide relevant emotional indicators that ultimately will allow us to assess depression. These indicators will be based in specific physical patterns of behaviors in daily activities, such as gait speed, verbal fluency/speed, sleep patterns, and device touch screen use. These patterns will be recorded, processed and monitored in unobtrusive and natural conditions in order to guarantee a more ecological assessment.

The following figure shows the proposed technical architecture:



A mobile application will measure and analyze the user's smartphone usage indicators while they are performing their regular daily activities, such as phoning, texting or simply moving around. These indicators include speech patterns (e.g. speaking rate or volume), interaction patterns with the device touch screen (e.g. key pressure intensity and speed), location patterns (e.g. location variation and duration) and also connection patterns (e.g. number of access points accessed).

This data together with self-reports (e.g. about sleep or mood) are inputs of out indicator detection engine, which will use machine-learning techniques to detect relevant variations in the user-specific baseline. These variations will trigger alerts to the user him or herself and to the therapist or researcher, so that relevant actions can be taken. We suggest that this will require a further assessment of the correlation between these types of measures and the emotional state related with the depression.

References

[1] Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information, 44*(4), 693-727.

[2] Scherer, K.R. (2001). Appraisal Considered as a Process of Multi-Level Sequential Checking, in K.R. Scherer, A. Schorr & T. Johnstone (eds), Appraisal Processes in Emotion: Theory, Methods, Research, pp. 92–120. New York and Oxford: Oxford University Press.

[3] Davidson, R.J., Pizzagalli, D., Nitschke, J.B. & Kalin, N.H. (2003). Parsing the Subcomponents of Emotion and Disorders of Emotion: Perspectives from Affective Neuroscience, in R. J. Davidson, K.R. Scherer & H. Goldsmith (eds), Handbook of the Affective Sciences, pp. 8–24. New York and Oxford: Oxford University Press.

[4] Stemmler, G. (2003). Methodological Considerations in the Psychophysiological Study of Emotion, in R.J. Davidson, K.R. Scherer & H. Goldsmith (eds) Hand- book of the Affective Sciences, pp. 225–55. New York and Oxford: Oxford Univer- sity Press.

[5] Harrigan, J., Rosenthal, R. & Scherer, K.R. (2005). *The New Handbook of Methods in Nonverbal Behavior Research*. Oxford: Oxford University Press.

[6] Bryant, C. (2010). Anxiety and depression in old age: Challenges in recognition and diagnosis. *International Psychogeriatrics*, *22*(4), 511-513.

[7] Galambos, C., Skubic, M., Shuang, W. & Rantz, M. (2013). Management of dementia and depression utilizing in-home passive sensor data. *Gerontechnology, 11*(3):457-468; doi:10.4017/gt.2013.11.3.004.00.

[8] Dickerson, R., Gorlin, E., & Stankovic, J. (2011). Empath: a Continuous Remote Emotional Health Monitoring System for Depressive Illness. *Wireless Health, 11,* 10-13.

[9] Faurholt-Jepsen, M., Brage, S., Vinberg, M., Jensen, H., Christensen, E., Knorr, U., & Kessing. L. (2015). Electronic monitoring of psychomotor activity as a supplementary objective measure of depression severity. *Nordic Journal of Psychiatry*, 69(2), 118-125.