

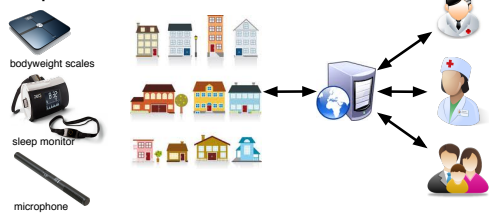
# Empath: Sleep Monitoring and Caregiver Displays for Depression Monitoring

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## Introduction

Depression is a major health issue that affects over 21 million American men and women each year. Depression often goes unrecognized and untreated, and even once treatment begins it is often difficult to measure its effectiveness. This poses particular challenges for the diagnosis and treatment of depression, particularly for those who avoid visiting a doctor or therapist due to social stigmas or a lack of energy. Currently, depression diagnosis is often based on subjective screening questionnaires or structured clinical interviews that rely on timely in-person visits as well as accurate recollections by the patient. This makes early detection of depression symptoms exceedingly difficult among this population. Yet early detection and treatment of this debilitating disorder has been shown to improve patient outcomes considerably. Along with depression's detrimental affect on mood, it can lead to other associated problems because of reduced social interactions, decrease in personal hygiene, increased alcohol use, and neglect of medications for current medical conditions. Assessment and treatment are often hampered by a lack of objective data to corroborate patients' retroactive self-reports about their current functioning; hence an objective symptom-monitoring tool could complement subject self-report measurement and enhance diagnostic accuracy.

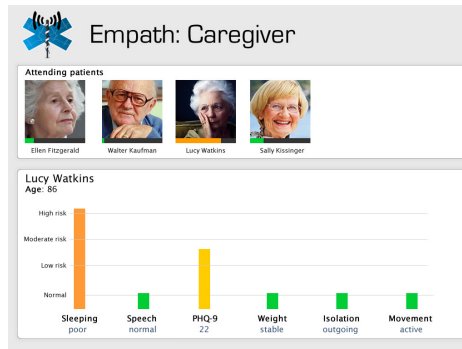
## Commodity Components      Deployments      Web Server      Stakeholders



The Empath system uses commodity components to sense information about lifestyle and behaviors. The webserver provides a gateway for caregivers to evaluate the mental health of their patients.

## Caregiver Interface

We developed a web interface that is designed especially for caregivers such as therapists, nurses, and doctors. At the main screen, the caregiver is presented a list of attending patients with an overall depression risk-factor. When a patient is selected, a summary of the basic behavioral factors: sleeping quality, social isolation, PHQ-9 score, weight, movement levels and speech analysis are presented in a column graph. Each factor is represented on a scale of 1-5 representing low to high risk. When a factor is selected, a new presentation of the data appears explaining the subcomponents that made up the factor score. The data is presented with a time-series plot or table however appropriate.



## Depression Risk Factors

- **Sleeping** – sleeping duration, number of interruptions, periods of restlessness.
- **Speech** – amount of inflection and the speech pause time.
- **PHQ-9** – index from the popular depression screening questionnaire.
- **Weight** – maintaining a healthy body weight, without gaining or losing 10% in the last two weeks.
- **Isolation** – amount of time spent away from house has decreased.
- **Movement** – amount a movement and ADLs that occur in the home.

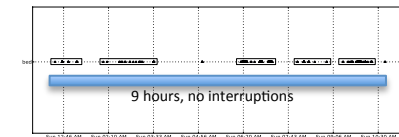
## Sleep Monitoring

A number of clinical studies have found that depression results in disruptions in sleep patterns. Sleep abnormalities are present in 80% of people with major depression. To measure the quality of sleep, there are self-report questionnaires such as the Pittsburgh Sleep Quality Index. However, studies have shown that subjects with insomnia may not be accurate in their subjective report of sleep latency, sleep duration, and number of disturbances. Therefore, there is need for objective instruments that can be used where subjective ratings fail. To date, there are few low-cost and unobtrusive sleep monitoring systems. To detect sleep cheaply and non-invasively, we demonstrate a new solution using Synapse SNAPpy motes for the collection and wireless communication of data.



Sleep is monitored using three tri-axis accelerometers placed on the mattress. Changes in pressure cause deflections in the angle of the sensors. The data is transmitted wirelessly to a base station.

The sleep monitoring algorithm converts discrete bed movements to sleeping activity segments. The first stage performs segmentation on the movement data using a rule that a sleeping segment has a certain number of movements and lasts for a certain duration. Next, segments are joined if no other sensors in the apartment have fired such as a refrigerator, toilet, etc. The assumption, at least for single person homes, is that if no other sensors fire, you can assume the patient is still on the bed.



Sample of data from one night of sleep. A threshold filter is applied to recognize binary events relating to sleep periods and restlessness.

## Acknowledgements

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