Enabling health, independence and wellbeing for psychiatric patients through personalised ambient monitoring: PAM

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www.pam-research.org
Background

• 1 in 10 of the UK population will suffer a disabling anxiety disorder at some stage in their life whilst 91 million working days are lost per year due to mental health problems and the cost to the country is £32 billion in lost productivity and treatment costs

• PAM will allow patients to select off-the-shelf technology that will monitor their “activity signatures”

• Will use a set of multiple discreet sensors worn, or in a person’s home, coupled to a computer system programmed to detect changes in activity signatures

• These can then be used to issue automatic alerts to the patient, their family, or their doctor, thus providing the capability to avert debilitating episodes
The research questions

• This project will address two questions:
  
  – Is it possible to obtain, in an automatic, ambient and unobtrusive manner, ‘activity signatures’ from the mentally ill that provide information about the trajectory of their health status?
  
  – If this is so; can this information be used to assist their healthcare?

• ‘Activity signatures’ are already collected in a paper-based format by healthcare workers who tend the mentally ill

• The intention is to automate this process so that relevant data is collected and processed on a regular basis in an ambient, unobtrusive manner that is acceptable to the individual being monitored
## Bipolar Disorder (Manic depression)

<table>
<thead>
<tr>
<th>Depressive Episodes</th>
<th>Hypomanic Episodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depressed mood and general sadness</td>
<td>Inflated self-esteem, flight of ideas</td>
</tr>
<tr>
<td>Lowered activity, diminished interest in all.</td>
<td>Decreased need of sleep</td>
</tr>
<tr>
<td>Significant weight loss or gain</td>
<td>Talkativeness / pressure to keep talking</td>
</tr>
<tr>
<td>Insomnia or hypersomnia</td>
<td>Distractibility. Attention is too easily drawn to unimportant stimuli</td>
</tr>
<tr>
<td>Increased / decreased psychomotor activity</td>
<td>Increase in goal-directed activity</td>
</tr>
<tr>
<td>Fatigue and loss of energy</td>
<td>Excessive involvement in risky activities (physical, financial etc.)</td>
</tr>
<tr>
<td>Diminished ability to concentrate and indecisiveness.</td>
<td>Excessive and unnecessary movements</td>
</tr>
<tr>
<td>Thoughts of death and suicide</td>
<td></td>
</tr>
</tbody>
</table>

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The technologies behind PAM
Behavioural Analysis

- Patterns leading to episodes (prodromes)
- Episodes
  - Type
  - Frequency
  - Duration
- The unusual

- Prodromes for Bipolar Disorder:
  - Manic
  - Depressive
- Sleep disturbance
- Mood changes
- Psychotic symptoms
- Psychomotor symptoms
- Suicidal ideas and intent
- Appetite changes
- Anxiety levels

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Potential data sources

- Fusion of different sources
  - Accelerometry
  - Diary / Questionnaire
  - Mobile phone positioning / GPS
  - Physiological sensors: Heart rate, temperature
  - Ambient sensors: door contacts
- Redundancy amongst sensors
- Cover all locations
  - At home → ambient sensors?
  - Ambulatory → wearable sensors?
  - Mobile phone → partially wearable

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Potential sensor scheme

Audio sensor (microphone)

Analog sensor (e.g. light level)

Analog sensor (e.g. light level)

Bluetooth module

A/D converter

GSM enabled Wireless processor

Global data receivers

GPRS

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E.g. tracking movement & position

Off-the-shelf GPS module

BT enabled accelerometer

logfile.txt

13 Feb 2008 13:06:41; G; 5256.0723; -112.181; 0.0;
13 Feb 2008 13:06:42; A; 0.044; -0.888; 0.484;
13 Feb 2008 13:06:44; A; 0.036; -0.892; 0.492;
13 Feb 2008 13:06:45; A; 0.036; -0.892; 0.496;

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GPS positioning

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Tri-axial accelerometers

walking

at a lecture

activity over time

clustered activity
State-of-the-art Health Sensor Networks

- Wearable Sensor Networks & Body Sensor Networks for medical and psychiatric monitoring is active an research area:
  - Alarm-Net
  - CodeBlue
  - Care in the Community
  - UbiMon
  - MobiCare
  - LiveNet

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Operational Research

• Operational Research is concerned with applying scientific and analytical methods to solving real-world problems

• OR has been applied to healthcare problems for many years: e.g. optimal allocation of scarce resources, scheduling operating theatres, improving patient flows and reducing waiting times, evaluation of treatments

• OR modelling allows safe experimentation with scenarios which may be costly, difficult, time-consuming or even unethical to test in the real world

• Modelling will allow us to test PAM under varying circumstances, such as the failure (or deliberate removal) of one or more of the sensors, or a patient’s unwillingness to have sensors in specific locations, or the limited availability of various types of data

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Computer simulation

- Computer simulation captures the uncertainty, randomness and variability of the real world
- It can use both quantitative and qualitative data (expert opinion)
- Using a computer simulation model, we will test the performance and reliability of PAM in a range of different scenarios
- Simulation will provide information on the clinical value of the information that PAM could deliver
- It can “fill in the gaps” where real-world experimental data is missing

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OR modelling in healthcare

- Computer model of a disease process: e.g. breast cancer
- Takes a population of individuals through the course of disease – e.g. population of 20,000 women over 40 years
- Superimpose interventions (screening and treatment)
- Evaluate the effectiveness in terms of life-years saved
- Can include behavioural aspects, e.g. the probability of attendance for screening
- Can do cost-effectiveness analyses to compare policies
- Can refine results by using qualitative measures such as Quality Adjusted Life Years (QALYs)

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Simulation modelling in PAM

- Population data (demographics etc)
- Clinical data
- Performance of PAM
- Acceptability
- Technical performance
- Software
- Sensors
- Communications
- Quality
- Reliability
- Individual characteristics: family support, clinical history etc
- Other contextual factors
- “Natural history” model of disease process (state transition model)
- Choice of sensors
- Outcomes: patient wellbeing and satisfaction; fewer episodes of major illness; reduced need for hospital admission
A conceptual disease state transition model

Well

Minor Symptom

Major Symptom

Depression

Death

Minor Symptom

Major Symptom

Manic

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Factors that affect the model

- patient factors: *general health, education, physiological*
- contextual factors: *home environment, office, car, etc*
- communication factors: *family, friends, neighbours, etc*
- event factors: *appointments, social, etc*
- environmental factors: *weather, temperature, humidity, etc*
- activities: *personal appearance, leisure, foods, etc*
The next steps
Risks

1. Ethical approval.

2. Social acceptability – we will involve the user community from the start and the design of the system will respond to their ambitions and concerns.

3. Technical risk – the investigators are at institutions with other active projects that are building capabilities that will support and enhance this work.
The next steps (in parallel)

- Formation of the steering committee
- Pose specific research questions to address in Bipolar Disorder
- Ethical approval
- Recruit test subjects
- Run blind limited time trial
- Report
- Develop sensor technologies
- Develop sensor(s) platform
- Model BD system to optimise and personalise system
- Develop signal processing approaches for data management and behavioural assessment

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Further on Dissemination

- In addition to the usual journals, magazines, and conferences for both research and medical practise, it is proposed to:
  - “target” mental healthcare practitioners and managers more directly. Hence we will take a stand at an appropriate medical conference
  - Running workshops in collaboration with mental health charities
  - A website will has been developed, not simply to tell the project story, but one to engage a wide range of practitioners
  - We foresee tutorials and software being offered, and later a forum for the use of practitioners interested in ambient technology in a mental healthcare situation.
  - Cafes Scientifiques will be used as a way of informing the lay community about our work.

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Questions?