Remote Monitoring of COPD Patients using Speckled Computing – the Elgin Experience

Prof. D K Arvind
School of Informatics, University of Edinburgh
Partners

- The Moray Council
- NHS Grampian
- The Maryhill GP Practice, Elgin
- Centre for Speckled Computing, University of Edinburgh
Centre for Speckled Computing

Informatics Forum

Research

Ideas
Algorithms
Platforms
Software

End-users

Appleton Tower

Evangelism,
Partnerships

Potential Customers

Proof-of-Concept
Demonstrators

Commercialisation

Application Products
COPD

- 7% of world population and growing
- 3.7 million in the UK; 100,000 in Scotland
- Most common reason for hospital admissions in Scotland
- £100M - Direct cost to NHS in Scotland in 2004-5

“COPD is the mother of long term conditions”
Managing COPD

• Patients reported symptoms – unreliable and inaccurate

• Indicators of exacerbation
  • Increase in breathlessness
  • Changes in respiratory rate and breathing pattern
  • Reduction in activity

• Pulmonary rehabilitation to reduce recurrence of exacerbation

Continuous remote monitoring of Respiration and Activity
Unmet Healthcare Need

- Respiration – one of the four vital signs monitored in a SEWS chart
- Identify early exacerbation in COPD
- Support pulmonary rehabilitation post exacerbation

“Monitoring of patients with COPD at home may help NHS boards avoid costs of £1,000 per patient per year”

Source: A Review of Telehealth in Scotland, 2011
• Specks: miniature devices combine sensing, processing and wireless networking
• Wireless patch for measuring respiratory rate, respiratory effort and activity
• Continuous remote monitoring which transmits data via a base-station to a secure server via a broadband interconnection
RESpeck Device

- Wireless patch with a three-axis accelerometer
- Sealed case and self-adhesive pouch
- Measures chest wall rotations as the wearer breathes
- Provides a respiratory effort waveform, respiratory rate and patient activity data
Recovery of flow rate waveforms

Healthy subject, seated, normal breathing. Device placed at lower costal margin, below ribs. Correlation $r = 0.9597$ (over 8 minute capture)
Comparison of Cannula and Orient Respiratory Rate Measurement

- Cannula (airflow pressure)
- Orient (rotation rate)
- Instantaneous Respiratory Rate (cannula)
- Respiratory Rate (10s avg) (cannula)
- Instantaneous Respiratory Rate (orient)
- Respiratory Rate (10s avg) (orient)

Breathing Rate (BPM) vs. Time (mins)
Wireless Healthcare of COPD

- Wireless patch worn on the torso
- Re-useable wireless sensor module
- Contained in a single-use sleeve for hygienic attachment to the torso
- Data collection and processing in a base-station via ultra low power wireless link
- Transmitted via broadband internet or via GPRS to server
- Remote respiratory monitoring service
Respiratory Monitoring Service

• Daily reports summarising hourly trends
• Option to access historical data
• Respiratory rate, respiratory effort/flow, activity, heart rate, cough frequency, speech episodes
• Remote examination of patient’s breathing in real-time
Patient-centric design

- Long-term wear
  - Light-weight - 17gms (incl. battery)
  - Unobtrusive - 4.5 x 3.7 x 1.3 cm
  - Battery lifetime - 12 months

- Ease of use
  - No recharging of batteries
  - Data stored on wireless patch and downloaded to the base-station when within range – no manual intervention

- Remote monitoring of performance of sensor devices for scalable deployment
  - Diagnostic data on sensor performance
  - Wireless patch replaced due to malfunction or before the battery runs out
Validation on postoperative subjects

with Dr Gordon Drummond (Royal Infirmary of Edinburgh & University of Edinburgh) 2010

• 19 gynaecological patients, who received Patient Controlled Analgesia

• Analysis performed over 5 minute epochs of synchronised accelerometer and nasal pressure signals

• Breaths were identified in the nasal pressure signal, which were then matched to a breath from the corresponding orient signal

• The instantaneous respiratory rate of these matched breaths were compared
Summary of results

- 248 hours of breathing were studied
- Successful transmission 94% of the time
- 119,765 valid cannula breaths
- 105,416 matched to Orient breaths
- Instantaneous respiratory rates agree to within 2BPM for 86% of matched breaths
- Mean absolute difference: 0.6BPM
- A reliable measure of respiratory rate was possible in 95.4% of the 5-minute epochs
Simultaneous oxygen usage and acceleration data were obtained for 4 healthy subjects. The rate of change of acceleration provides a good estimate of energy expenditure.
Oxygen consumption v/s physical activity

VO₂

SPECK

minutes

Physical Activity (AU)

VO₂ (mL/Kg)

SPECK Physical Activity (AU)

r=0.93
p<0.0001
Simultaneous RR/Activity in COPD patient

COPD - Respire 7, capture 12

1: Breathing signal

Rise in respiratory rate

Increase in activity level
Wireless patch with 3-axis accelerometer measures rotation of the chest wall – a good proxy for respiratory flow


Validated against nasal pressure in clinical trials – a good match in respiratory rate


Accelerometer and nasal pressure used in tandem to monitor central nervous system respiratory depression and upper airway obstruction

The Moray Study

- Study use of wireless respiratory and activity monitoring in a community setting
- Evaluate impact on the stakeholders: patients, clinicians, nurses, health authority
- Confirm usefulness of data in Primary care setting
Home Monitoring Data Flow

Patient leaves hospital with RESpeck monitor

Acceleration data via secure Internet connection

Respiratory rate and activity report

Maryhill Health Centre
Elgin

Centre for Speckled Computing
University of Edinburgh
Respiratory Rate and Activity
Magenta, 24 May - 7 June

Date and hour

Mean activity level
Rate (BPM)
24 per. Mov. Avg. (Rate (BPM))
24 per. Mov. Avg. (Mean activity level)
Evaluation

• Detect early onset of exacerbations to avoid hospital admissions
• Facilitate early discharge from hospital
• Reduce patient anxiety
• Clinical view on usefulness of data
• Health economics – including clinical time saved, hospital admissions prevented (comparison with previous position)
• Patient view – general feelings/reduced anxiety
• Carbon footprint – extending the reach of the Practice
Patch that lets GP give you a check-up from miles away

By FRANK URQUHART
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PATIENTS suffering from respiratory problems are taking part in a groundbreaking and potentially life-saving project which allows doctors to monitor them remotely through a body patch.

• Device allows GPs to measure respiratory flow and rate of patients remotely

• Patch is being piloted in community setting after successful hospital trials

The small electronic patch, worn on the patient’s chest, measures respiratory flow and rate and sends the data through wireless technology to a GP practice in Elgin, enabling the patients in Moray to be constantly monitored in the comfort of their own homes.

The system, developed by the Centre for Speckled Computing at Edinburgh University, has already been successfully tested at trials in hospitals in the city, but it is now being piloted for the first time with patients in a community setting.

In a separate development, patients at the same Moray health practice are testing another revolutionary remote healthcare system which allows them to send daily readings of their blood pressure, oxygen levels, temperature and pulse to doctors. It is hoped the two pilot schemes will lead to the early identification of problems, help reduce hospital admissions and ultimately save lives.

Ian Cameron, 58, a patient at the Maryhill practice in Elgin, has already used both devices and praised the initiative.

Mr Cameron, a former demolition worker, suffers from chronic obstructive pulmonary disorder (COPD), which affects his breathing.

He said: "I was happy to try anything which could help me to stay well and it's good to know I'm being so closely monitored. I wore the patch for a month. It's only about one and half inches square. I thought it might bother me, especially at night, but I quickly stopped noticing it."

He added: "I have now started using the other device. I connect up to a machine like a laptop and it takes readings of my blood pressure, oxygen levels, temperature and pulse every morning."

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Centre for Speckled Computing
10 Crichton Street
Edinburgh EH8 9AB
Scotland, United Kingdom
+44 (0)781 765 4055
dka@inf.ed.ac.uk