Wearable Sensing Application- Carbon Dioxide Monitoring for Emergency Personnel Using Wearable Sensors

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Targeted gases

Carbon monoxide - CO
- Odorless, colorless, tasteless, toxic gas
- Produced by the incomplete combustion of fossil fuels
- Present in atmosphere as a trace gas, 350-400 ppm
- Colorless, odorless, non-combustible gas
- Combustion of fossil fuels and deforestation
- Snow blindness, headache within 1-2 hours
- Dizziness, nausea, convulsions within 45 minutes, insensible in 2 hours
- Concentration of CO
- Inhalation time and toxic in air
- 50 ppm: Safety level as specified by the Health and Safety Executive
- 200 ppm: Slight headache within 2-3 hours
- 400 ppm: Frontal headache within 1-2 hours
- 800 ppm: Dizziness, nausea, convulsions within 45 minutes, insensible in 2 hours
- 10000 ppm: Drowsiness
- >20000 ppm: More frequent, deeper respiration
- 30000 ppm: Breathing rate doubles
- 50000 ppm: Serious oxygen deprivation resulting in permanent brain damage, coma and even death

Carbon dioxide - CO₂
- Sensor supplier: Alphasense UK
- 3-pin sensors
- 14.5 mm diameter, 12.5 mm height (including pins)
- CO₂ sensor electrodes: reference, working
- Principle of a Potentiometric Sensor for Gases: The signal is measured as the potential difference (voltage) between the working electrode and the reference electrode. The working electrode potential depends on the concentration of the CO₂ in the gas phase.
- CO₂ gas is more dense than air and tends to accumulate in low heights. The CO₂ sensor has been integrated in a specially designed boot pocket.
- Module dimensions: 5.5x4x1.5 cm
- Nickel hydride rechargeable battery
- 2.4 GHz Zigbee module with an integrated ceramic antenna - Jennic JN5139-001-M00 802.15.4 RF Module
- Signal captured using a base station, connected to a PC and monitored using HyperTerminal.
- CO₂ sensor response
- Wirelessly transmitted signal from CO₂ sensor calibration (range atmospheric to 42800 ppm CO₂). Sensor was enclosed in an airtight chamber and CO₂ was injected.
Problem: CO2 sensor variability

It is not possible to find common slope and intercept for all sensors!!

1-1.5 V response for a single injection Resulting in 42000 ppm

CO2 sensor- using calibration parameters

Using slope and intercept obtained from sensors calibration it was possible to successfully predict the sensors response in volts for each known concentration of CO2

Prior to using any sensor/wireless module, calibration of the particular sensor will be needed and the obtained slope and intercept will have to be used as input parameters for each module.

Once the sensor needs to be replaced, a new set of parameters characteristic for a new sensor will need to be used.

Future activities

- Re-programming the modules to account for calibration factors
- Full integration of CO/CO2 sensors into the garment
- Wireless transmission: communication of on-body base station and the remote station
- Evaluation of prototypes in laboratory conditions
- Evaluation of prototypes in-field conditions

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