# Introduction

This project will explore the use of wearable sensors to monitor breathing rate and oxygen saturation for the purpose of detecting the occurrence of an apnoea during sleep. The accuracy of a triaxial accelerometer in identifying respiratory rate will be determined in conjunction with blood oxygen analysis using a pulse oximeter.

Currently, the only method of long term monitoring of respiratory rates in sleep apnoea patients at home is through data collected from the memory card of their CPAP/APAP machine; an apparatus providing the user with a constant (or automatic) flow of air pressure. As many sufferers have difficulty tolerating this form of treatment, this project will explore an alternative, non-obstructive method of collecting breathing and blood oxygen data for determining the frequency of apnoeas, for both short and long term analysis.

If the combination of these sensors proves to be an accurate monitoring system for sleep apnoea, the system could be used by individuals with mild to moderate sleep apnoea, for those who are not suited to using a CPAP/APAP machine for treatment, or those who would like to self monitor their condition and view their long term progression. Due to the relatively low cost of these sensors and the possible aggregation of data over long periods, commercial use of this system could significantly reduce patient monitoring and treatment costs. The use of this system in conjunction with weight monitoring could also allow users to recognise the impact of weight fluctuations on their condition.

## Research

Sleep apnoea is "the state [during sleep] when airflow into the lungs is fully or partly blocked and when oxygen drops to relatively dangerous levels". An apnoea can be defined as a prolonged pause in the intake of air, often coinciding with continued respiratory effort. It tends to be followed by a loud gasp or snorting noise as the individual regains a normal breathing rate. Resulting arousal from sleep is common.

Approximately 200,000 people in Ireland are suffering from some form of sleep apnoea, with only 10% of those seeking treatment. The condition is associated with hypertension, cardiovascular disease, depression, glaucoma and diabetes mellitus. Common symptoms that sufferers report include excessive daytime sleepiness, frequent mood swings and impaired short term memory, reduced libido and morning headaches. In addition to the above, studies have shown that sufferers are at an increased risk of occupational injuries and are seven times more likely to be in a motor accident compared to those without the condition. The typical demographic is middle-aged men with a large neck circumference and are habitual snorers. Sleep apnoea is a highly prevalent and grossly unreported condition. It is associated with some of Ireland's deadliest fatal diseases and the technology currently in use to support suffers is expensive, invasive and a huge deterrent to seeking treatment.

## Current Technology

The current gold standard in sleep apnoea treatment is the use of CPAP or APAP devices. A CPAP (Continuous Positive Air Pressure) machine consists of a mask which covers the nose and/or mouth affixed to the head with various straps. A tube directs a continuous airflow from a bedside machine to the mask. The pressure maintains an open airway, thus avoiding apnoeas. An APAP (Automatic Positive Air Pressure) device will automatically adjust the air pressure based on feedback from the patient's current breathing. Data from these devices is interpreted either by a respiratory specialist, a third party sleep analysis company, or through user friendly software applications with very basic graphical representations.

One alternative solution recently brought to market involves a system of sensors connected to the body and sending heart rate and respiratory information directly to the physician. A series of electrode sensors are attached with wires to the body with adhesive pads. Additionally, nasal and pulse oximeter sensors are attached. The entire system feeds information to a unit worn on the chest for later transmission to a sleep specialist.

CPAP/APAP therapy is prescribed following a diagnostic polysomnogram usually performed in a hospital or sleep clinic.

# Research

Research into sleep apnoea follows three distinct causal paths; where there is either neurological involvement, muscular involvement, or a combination of the two.

# High Level Design

# Detailed Design

# Implementation

# Testing

# Results

# Future Work

# Conclusion

# Bibliography

|  |  |
| --- | --- |
| [1] | A. Scheck, Lippincott's focus on cardiovascular disease and sleep apnea, Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins, 2010. |
| [2] | D. Smith, *Irish Sleep Apnoea Trust,* 2014. |
| [3] | M. E. U. P. M. S. Larry J. Findley, “Automobile Accidents Involving Patients with Obstructive Sleep Apnea,” *Pulmonary Division, Department of Internal Medicine, University of Virginia, Charlottesville, Virginia,* vol. 138, no. 2, October 1987. |
| [4] | S. Wilson and D. Nutt, Sleep Disorders, New York: Oxford University Press, 2008. |
| [5] | S. B. C. D. M. Luo, “An inexpensive accelerometer-based sleep-apnea screening technique,” in *Aerospace and Electronics Conference (NAECON)*, Fairborn, OH, 2010. |
| [6] | M. D. F. F. C. Virend K. Somers, M. C.-C. David P. White, M. C.-C. Raouf Amin, M. F. F. William T. Abraham, M. F. Fernando Costa, M. F. Antonio Culebras, M. P. F. Stephen Daniels, M. D. F. F. John S. Floras, M. Carl E. Hunt, M. F. Lyle J. Olson, M. D. F. Thomas G. Pickering, M. F. F. Richard Russell, R. P. F. Mary Woo and P. Terry Young, “Sleep Apnea and Cardiovascular Disease,” *Journal of the American College of Cardiology,* vol. 52, no. 8, 2008. |
| [7] | C. W. H. C. B. M. G. J. M. Sabine Horstmann, “Sleepiness-Related Accidents in Sleep Apnea Patients,” *SLEEP, Department of Neurology, University Hospital, Bern, Switzerland,* vol. 23, no. 3, 2000. |