The development of a low-cost chest wall motion analysis device
Comparing the Developed System with Opto-Electronic Plethysmography (OEP)

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Introduction
Respiratory disease is the leading cause of death in the UK (18%) and accounts for 920,000 disability adjusted life years lost. It is the most frequent cause of disease in primary care (13%) in all age groups and the second most common cause of chronic condition (19%).

Lung function is commonly assessed by a forced exhalation flow into a spirometer. It requires a mouth piece and the nose occluded by a clip, which makes the subject aware that breathing is being measured and interferes with the natural pattern of breathing. It is impractical for prolonged measurement, limits subject's mobility and introduces additional dead space.

Lung function assessed by chest wall motion analysis may better reflect a patient's symptoms of breathlessness and devices have been developed including magnetometers; Respiratory Inductance Plethysmography; Optoelectronic Plethysmography (OEP) and Structured-Light Plethysmography (SLP).

However, the available technology is cumbersome, expensive, time consuming and difficult to interpret. Thus, novel, cost effective and ‘useable’ technology is required.

New Kinect-Based System
Microsoft Kinect is a human tracking peripheral used in the gaming industry for the Microsoft Xbox to provide 3D motion capture capabilities.

![Kinect and Multi-Kinect Scan](Figure 1 – Kinect and Multi-Kinect Scan)

To enable chest wall motion analysis, a system comprising four Kinect sensors was developed. The sensors were calibrated and images from each frame combined to create a 3D representation of the torso (Figure 1).

Opto-Electronic Plethysmography (OEP)
OEP is a marker based motion capture system. For the purposes of this project, the system utilised 89 reflective markers were attached to the patients torso, and 8 cameras used to monitor the movement of the markers (Figure 2).

![OEP in use](Figure 2 – OEP in use)

Method
The main experiment performed in this study was the comparison of data from OEP, with the Kinect-based system. The two systems were set up as shown in Figure 3 and captured 5 patients simultaneously.

![Experimental Set-Up](Figure 3 – Experimental Set-Up)

Results
Results were compared for 6 movements which included tidal volume, breathing frequency, minute ventilation, inspiratory capacity, expiratory reserve volume and vital capacity.

As an initial evaluation, correlation of the two systems was calculated using a Pearson’s correlation coefficient. A graphical representation of the correlations can be seen in Figure 4.

Comparison of the two system using a Bland-Altman analysis was also conducted and this can be seen in Figure 5.

Results showed a good correlation between the two systems, but improvement is needed. This was predominantly due to outliers in the dataset.

Conclusion
This study demonstrates a new low-cost, markerless chest wall motion analysis system. The system is compared against the OEP system and demonstrates promising results. Further refinement of the system is now required to generate results of increased accuracy.