DEVELOPING A WEARABLE MICROWAVE INSTRUMENT FOR DETECTING THORAX INJURIES—TESTS ON A PNEUMOTHORAX PHANTOM

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1. Introduction

Traumatic injuries is the leading cause of death for young people. A quarter of these deaths are a consequence of thorax injuries [1]. Pneumothorax (PTX) is a collection of air in the thoracic cavity caused by a rupture in the membranes surrounding the lung. Failure to diagnose and swiftly treat a PTX that is enlarging may cause patient death [1]. There is a need for an instrument to be used in the prehospital setting for objective detection of PTX.

2. Materials and Methods

A wearable microwave instrument with six antennas was constructed using a leather belt and in-house fabricated patch antennas; measurements were performed on healthy volunteers (Figure 1). A simplified model of the human thorax was constructed using plastic containers of suitable sizes, filled with an appropriate mixture of ethanol and deionized water to obtain realistic dielectric properties; a container in the shape of an elliptical frustum (inner volume 12 L, with the smaller ellipse as the base) represented the thoracic cavity, and two cylindrical containers (inner volume 2 L) formed the lung space (Figure 1). To simulate a PTX, the lung space was left empty and a plastic bag resembling a collapsed lung filled with a dielectrically suitable liquid was placed inside. Measurements were performed for PTX sizes of 10%, 20% and 50% in the left or the right lung; sixty measurements were randomly drawn from this dataset and represented the PTX observations. An additional sixty measurements were performed on a phantom without PTX. The belt was repositioned after every third measurement. Measurements were conducted in a random order. A classification algorithm based on finding the minimum distance to the subspace bases, which were calculated by singular value decomposition of the training data matrix, was used to distinguish between the measurements of No PTX and PTX. The leave-one-out approach was used, i.e. the sample to be classified was not included in the training data matrix, in order to not overestimate the classification performance.

3. Results & Discussion

Measurements of the human thorax and the thorax model showed similar characteristics. The classification algorithm differentiated PTX and No PTX (Figure 2). All No PTX and all except two PTX observations were correctly classified. This is an encouraging result for pursuing the development of an instrument for PTX detection in the prehospital setting.

References

[1] A. Sharma and P. Jindal, *Journal of Emergencies, Trauma, and Shock*, **71**, 34–41 (2008).

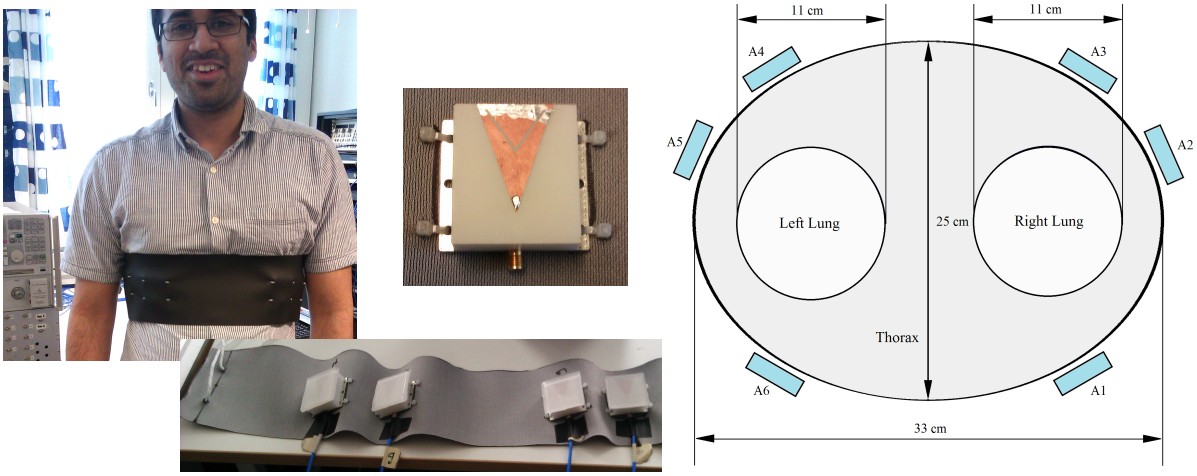

Figure 1: Left: The wearable microwave device (earlier version with four antennas). Right: Top view of the human thorax model, antenna locations are labelled A1–A6.

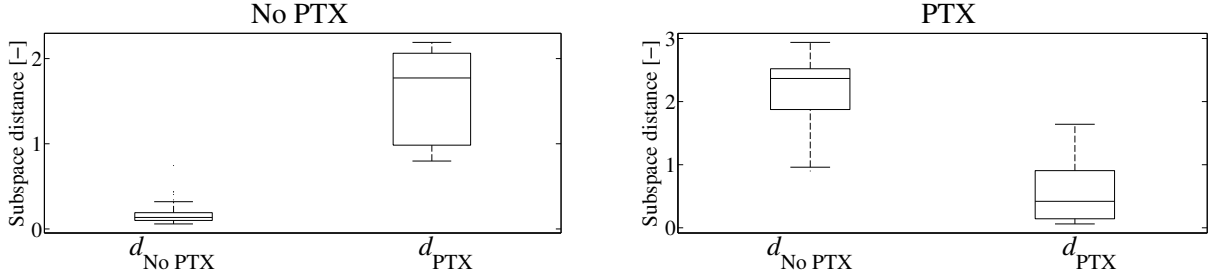

Figure 2: Box plots showing the distance to each subspace basis for the two classes, i.e. No PTX or PTX. The line in the middle of the box shows the median, and the bottom and the top of the box show the 25th and 75th percentile, respectively.