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CONTENT

• Body Armour: coverage
• Organ Location: limitations
• Solution
• Results
• Discussion
• Future Work
Function of Body Armour

• Personal Protective Equipment (PPE)
• Protect vital organs of thorax & abdomen \cite{1, 2}
• Protection-mobility tradeoff
• Evidence based design

\cite{1} Laing & Jaffrey. TR-3636 (2019)
\cite{2} Breeze et al. *J R Army Med Corps* (2015)
Coverage requirements

• No universal requirements

• National Institute of Justice:
  - Standards for stab resistance coverage of vital organs: heart, liver, kidneys and spleen

• Breeze\(^2\):
  - Essential organs: heart, great vessels, liver and spleen

Organ Location

• Medical imaging literature – centre mass of organs
• Lack of data: boundaries of organs – dependent on body size and shape / male versus female
• Consideration of breathing and postural conditions [1]
• Erect versus prone

Limitations of determining organ location

• Inappropriate imaging modalities: CT, MRI and ultrasound
  - Invasive / risks
  - Expensive
  - Inappropriate

• Goal is to be able to develop a method that can be easily used for all soldiers
Alternate solution?

• Existing methodologies\(^3\)

• For this work:
  - Low dose PA and lateral chest / upper abdomen x-ray images
  - 3D surface scan

Method

- PBU-60 whole body anthropomorphic phantom (Kyoto Kagaku Co. Ltd., Kyoto, Japan)
  - Includes lungs, heart, great vessels, liver, kidneys and spleen
Method

- PBU-60 whole body anthropomorphic phantom
  - Includes lungs, heart, great vessels, liver, kidneys and spleen
- Planar X-ray images, PA and Lat., and known image magnification factors.
  (X-ray unit: Carestream Health, Rochester, USA)
Method

• PBU-60 whole body anthropomorphic phantom
  - Includes lungs, heart, great vessels, liver, kidneys and spleen
• Planar X-ray images, PA and Lat., and known image magnification factors.
• External surface scan using a hand-held 3D scanner (Artec™, Leo 3D Scanner, Artec Group, San Jose)
Method

• PBU-60 whole body anthropomorphic phantom
  - Includes lungs, heart, great vessels, liver, kidneys and spleen
• Planar X-ray images, PA and Lat., and known image magnification factors.
• External surface scan using a hand-held 3D scanner
• CT scans and 3D reconstructions (Canon Aquilion One, Tochigi, Japan)
Method

- X-ray images saved in DICOM format; external surface scan in stereolithography (stl) format
- X-ray images were manually segmented using custom software (Orthovis v4 Matlab, The Mathworks, Inc., Natick, MA) [4]
- Multi-modality 2D–3D registration based on previous work [5] using segmented X-ray images and external surface scan
- Compare the created 3D registered model against ground truth, the CT scan data

Method

• Registration of 2D surface to 3D external scan in two planes:
  • Front (PA) and
  • Side (lateral)
Results – lung fields
Results – heart
Results – liver
Results – lung, heart and liver
Discussion

• Proof of concept work shows promising initial results of organ localisation from two low dose planar X-ray images\textsuperscript{[6]} and a 3D external surface scan
  - chest / abdo X-rays ≈ 0.7 mSv
  - chest / abdo CT scans ≈ 15 mSv

• Potential to classify soldiers into body shape groups based on organ location and external body shape

• Limitations
  - Anthropomorphic phantom only closely represent human X-ray attenuation characteristics
  - No breathing and postural changes

\textsuperscript{[6]} ARPANSA (2019)
Future Work

• Test method on humans and correlate to images acquired in a vertical MRI scanner
  - Show influences of gravity and breathing
• Build data sets of soldiers’ body shapes / sizes and organ locations, both male and female
References


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