Master's Thesis Engineering Technology

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Position determination of a gamma ray point source using a single layer Compton camera

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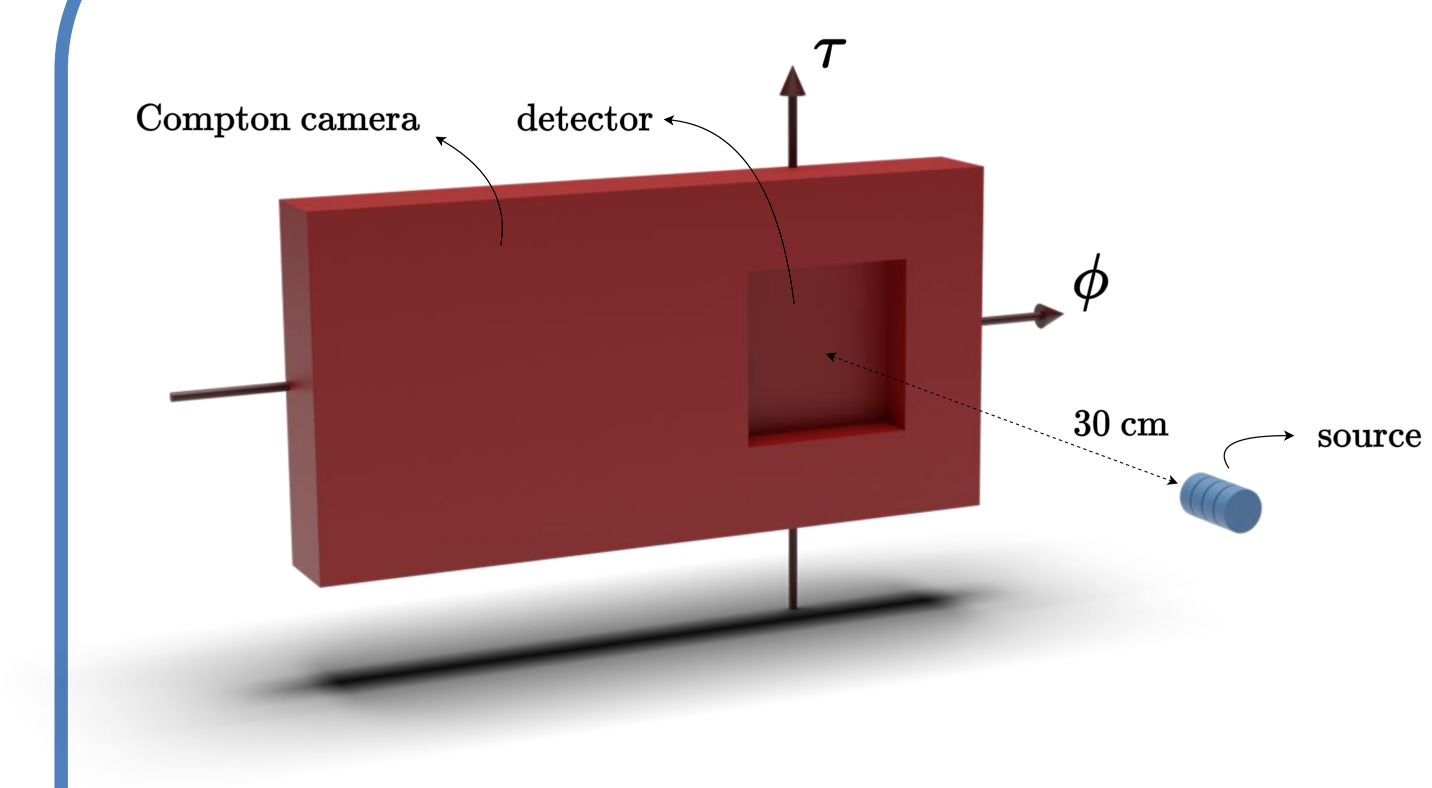
Problem statement

Before **nuclear decommissioning, human operators locate and characterise sources** by entering a facility and manually performing measurements. A **strict time limit** for these measurements ensures the health of the operators, but leads to **less accurate or incomplete measurements**.

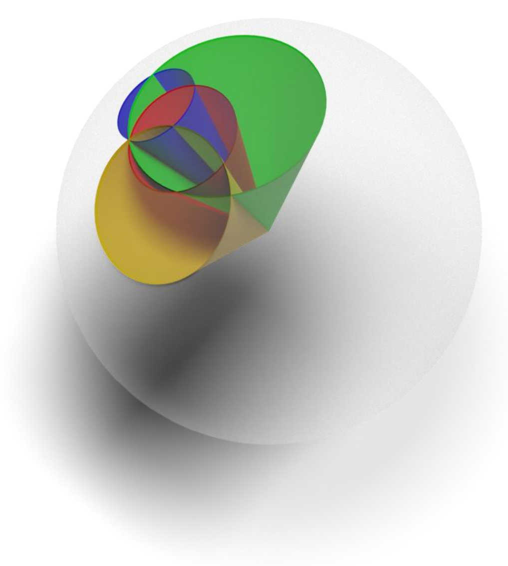
A mobile robot that maps the sources, using a **single layer Compton camera**, can be a viable alternative. This paper researches how to use the data from the camera to locate a point source.

Measurement setup



A **1 mm thick CdTe** single layer Compton camera detects the γ-radiation of a **^{137}Cs point source.**

Constructed method



Back-projection of Compton cones, reconstructed using the data from the camera, determines the two angles necessary to locate the point source. Two methods of back-projection are implemented and compared: **addition** and **multiplication**.

Results and discussion

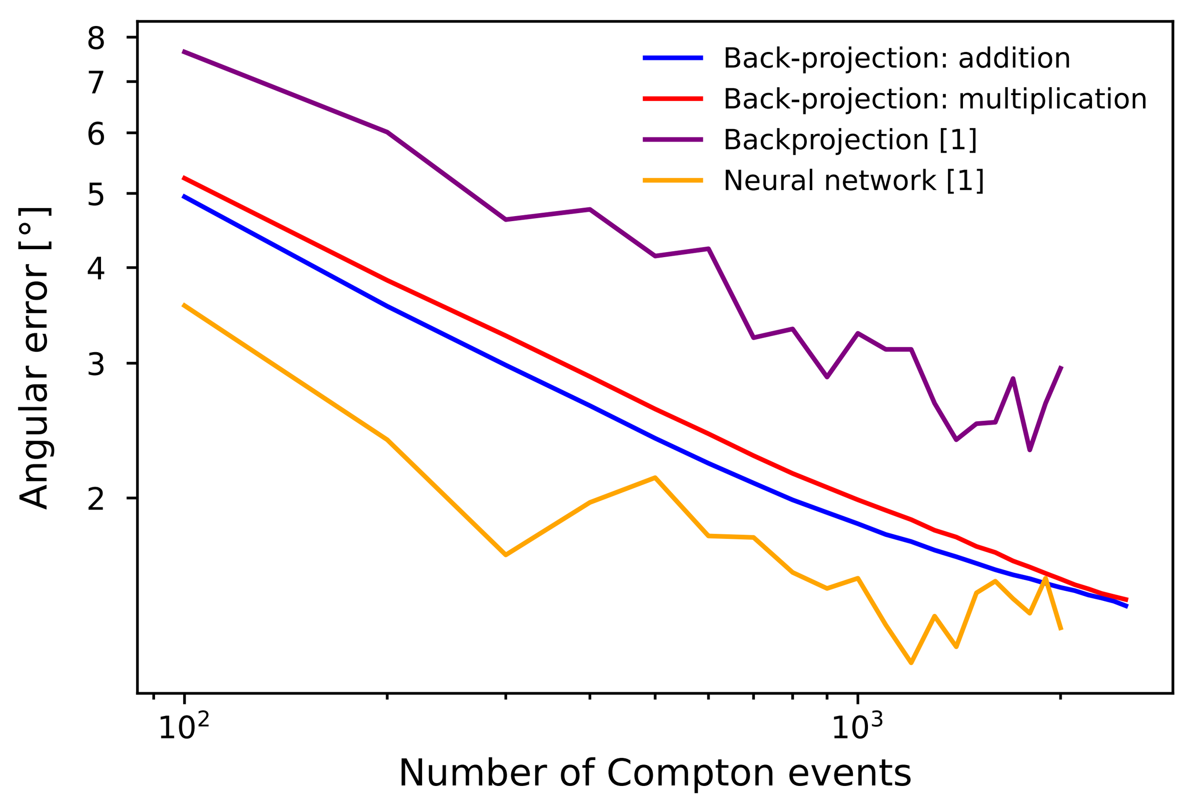


Figure 1: Angular error in function of number of Compton events

Figure 1 illustrates the **exponential descent** of the angular error in function of the number of Compton events for the implemented back-projection algorithms. Typically, addition is 6% more accurate than multiplication, but that percentage is larger for shorter measurement times and shrinks to zero for longer measurement times. When compensating for percentage of frames used (fig. 2), the implemented algorithms **outperform the back-projection implementation from [1] and can compete with their neural network**. Therefore, it can be said that the implemented algorithms **can compete with the current state-of-the-art**.

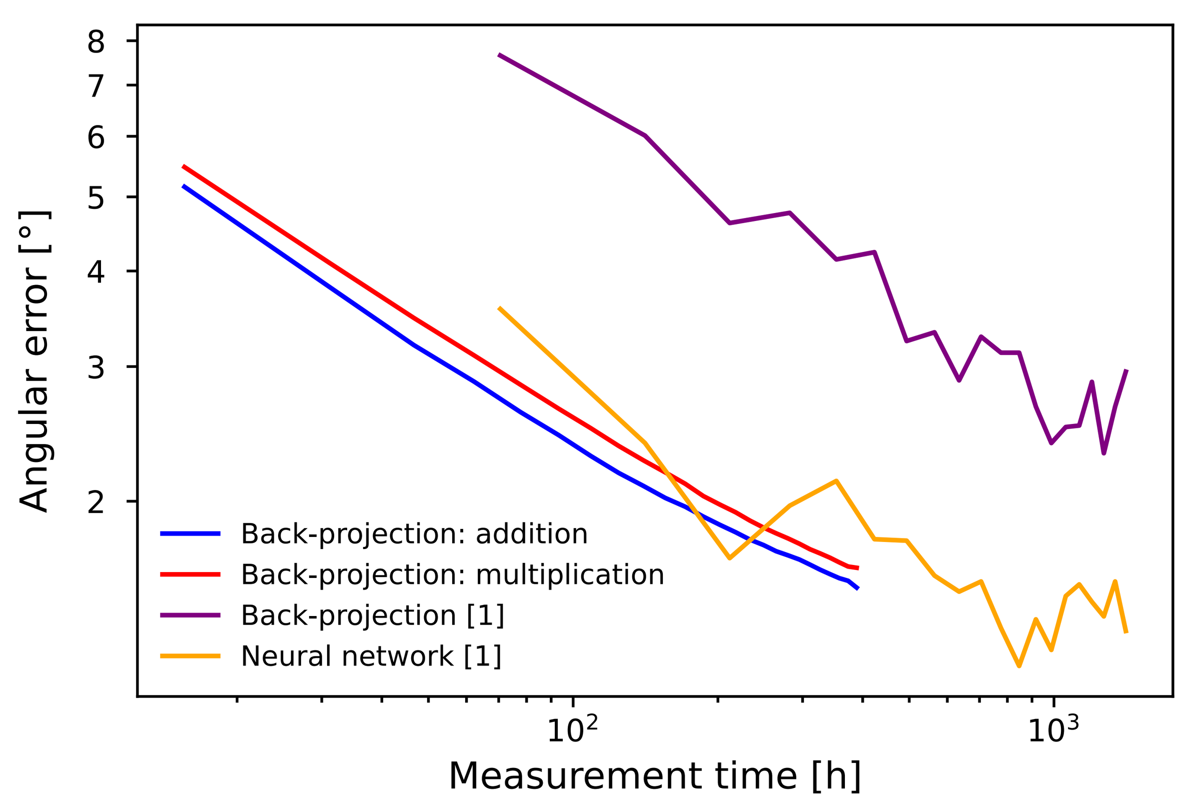


Figure 2: Angular error in function of measurement time for a source with an activity of 1 MBq

Conclusion

The obtained results can be used as a **first step in the localisation of a γ-ray point source**. However, this research involved a **simplified experimental setup in a controlled environment**, where the distance from the point source to the detector was known.

Further research and development is necessary in order to use a single layer Compton camera in a real-life nuclear decommissioning setting.

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[1] G. Daniel, Y. Gutierrez, and O. Limousin, "Application of a deep learning algorithm to Compton imaging of radioactive point sources with a single planar CdTe pixelated detector," *Nuclear Engineering and Technology*, vol. 54, no. 5, pp. 1747–1753, May 2022. doi:10.1016/j.net.2021.10.031.

GitHub

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