Explosion Yield Estimation using Machine Learning Methods

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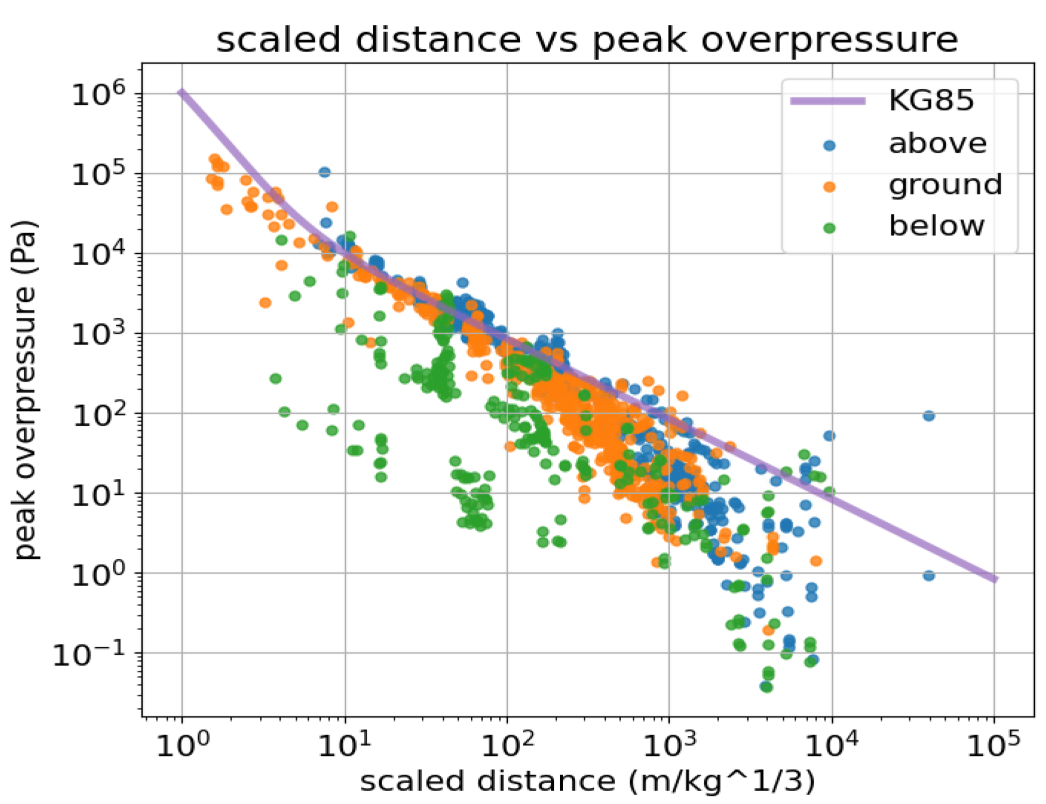
Motivation

- Proof of concept machine learning applied to acoustic explosion data for yield estimation.
- Gain insight for future applications on a growing explosion dataset collected on smartphones.

Mission Relevance

- Explosion monitoring and yield estimation is a vital part of nuclear non-proliferation monitoring.



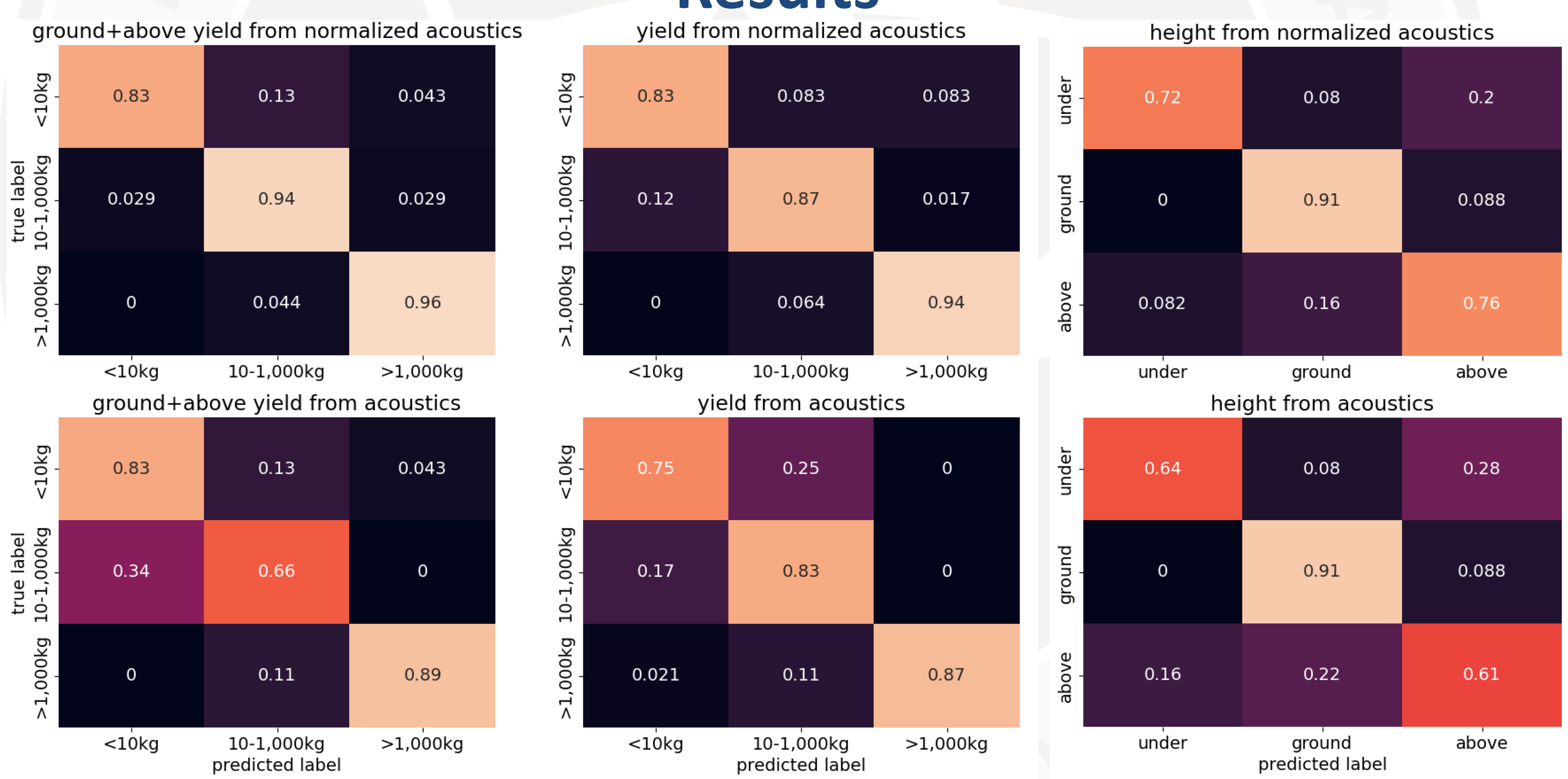
Data

- 2300+ acoustic explosion data from 26 events were sanitized and curated in collaboration with Keehoon Kim from LLNL

Technical Approach

- Effective yields were separated into 3 categories of roughly equal size.
- Height of Detonation (HOD) were separated into 3 categories.
- A 2 layered 1D Convolutional Neural Network were used for training.
- The models were trained with raw pressure data and normalized pressure data where amplitude information were stripped.
- Scaled Distance (<20m/kg$^{1/3}$, 20 - 200m/kg$^{1/3}$, >200m/kg$^{1/3}$)and Height of Detonation (under, ground, above) of the misclassified data were analyzed for interpretability of model performance.
- Underground data were removed for yield estimation comparison.

Results



- Confusion Matrix (Top) and Accuracy Breakdown Table (Bottom).

Target	Data Type	HOD	Accuracy	near range	mid range	far range	under	ground	above
Yield	normalized	ground + above	92%	100%	97%	88%		96%	89%
Yield	normalized	all	89%	79%	91%	89%	80%	88%	93%
Yield	raw	ground + above	80%	56%	94%	75%		82%	74%
Yield	raw	all	83%	57%	91%	83%	92%	73%	88%
HOD	normalized	all	82%	71%	82%	80%			
HOD	raw	all	75%	79%	79%	67%			

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Expected Impact

- Groundwork for applying machine learning methods to growing database of acoustic explosion data collected on smartphones.

MTV Impact

- Dataset and mentorship provided by LLNL.
- Future release of sanitized dataset planned with LLNL.
- Additional data collection with INL and NNSS.

Conclusion

- Normalizing the data improves the accuracy of the neural net.
- Near range data and far range data limit accuracy.
- Effective Yield and HOD were able to be classified in broad bins with limited data.

Next Steps

- Applying the machine learning methods to the explosion data collected on smartphones.

National Nuclear Security Administration