Aroma-based Localization in GNSS-denied Environments

Outline

- Olfactory navigation
- Data collection
- Machine learning algorithm
- Classifiers
- Results and analysis
- Summay

OLFACTORY NAVIGATION

Olfactory navigation can be described as the ability to reach a point from a distance just rely on the distribution of environmental odors.

- Homing Pigeons
  - Compass sense (Sense of direction)
  - Map sense (Sense of location)
- Salmon Run

https://australianmuseum.net.au/learn/animals/birds/feral-pigeon/

https://www.alaskaphotographics.com/alaska-photo-articles/alaska-salmon-photos/%3Ca%20href=%22https://alaskaphotographics.photoshelter.com/img-show/I0000SHTdjDBRyVA

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DATA COLLECTION

- Device

Chempro 100i
16 electrodes, 14 of them simultaneously measures ion mobility, rest two electrodes for airflow controlling

- Data Empty

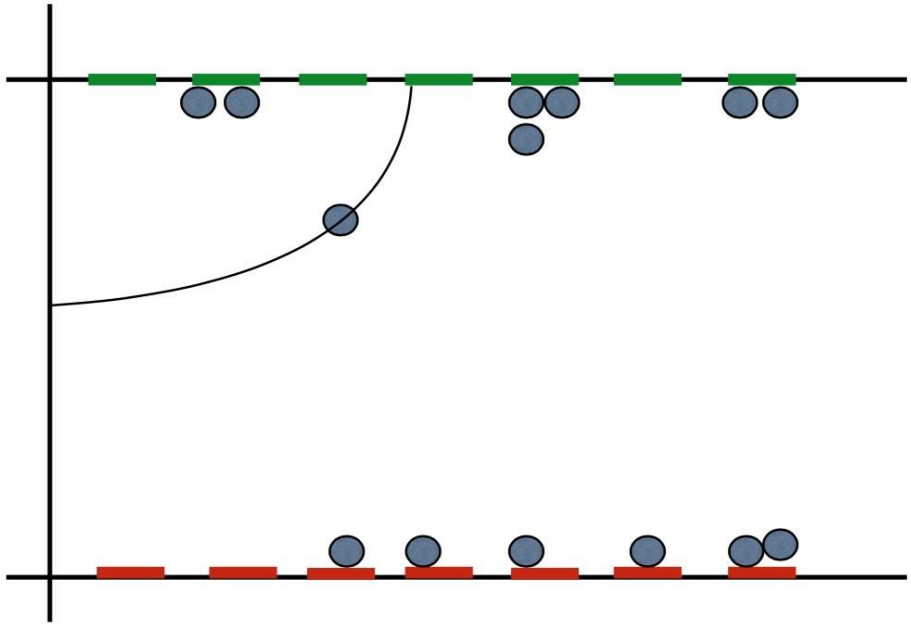
Contains 7 rooms with 14 dimensional IMS reading, duration around 600s in each room

- Data Crowded

Same as Data empty but different environmental conditions

https://www.environics.fi/product/chempro100i/

DATA COLLECTION (CONT.)



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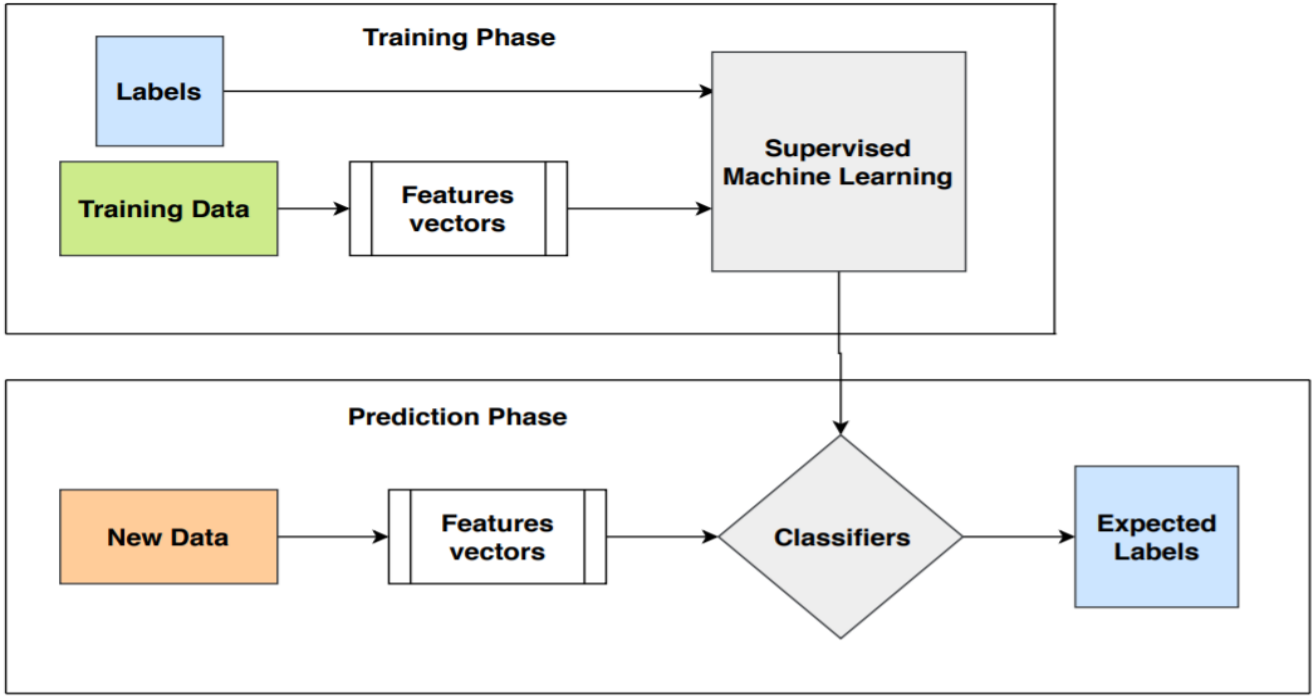
MACHINE LEARNING ALGORITHM



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CLASSIFIERS THAT USED

- **K-Nearest Neighbor (KNN)**

Distance metric : Euclidean, Minkowski, Manhattan, Cityblock, Cosine

- **Liner Discriminant Analysis (LDA)**

It is a method to find a linear combination of features that separates two or more classes of objects.

- **Support-Vector Machines (SVM)**

It performs classification by finding the hyperplane that maximizes the margin between two classes.

- **Random Forest Classifier (RFC)**

It creates a set of decision trees from a randomly selected subset of the training set and aggregates the votes from different decision trees to decide the final class of the test object.

- **Stochastic Gradient Descent (SGD)**

It is a very effective approach to discriminative learning of linear classifiers. SGD randomly picks one data point from the whole data set at each iteration to reduce the computations enormously.

EXPERIMENTAL RESULTS

Classifier	Distance	Classification Accuracy	Value of K
KNN	Euclidean	**37.56%**	5
KNN	Euclidean	37.33%	3
KNN	Minkowski	37.53%	5
KNN	Minkowski	37.21%	3
KNN	Manhattan	36.89%	5
KNN	Cityblock	36.94%	5
KNN	Canberra	29.83%	5
KNN	Cosine	29.97%	5
LDA	--	35.42%	--
SVM	--	34.05%	--
RFC	--	29.55%	--

Trained as crowded/Test as empty

Training data size 25%

Classifier	Distance	Classification Accuracy	Value of K
KNN	Euclidean	29.96%	5
KNN	Euclidean	30.21%	3
KNN	Minkowski	29.57%	5
KNN	Minkowski	29.89%	3
KNN	Manhattan	25.95%	5
KNN	Cityblock	25.94%	5
KNN	Canberra	29.66%	5
KNN	Cosine	**34.12%**	5
LDA	--	31.47%	--
SVM	--	31.31%	--
RFC	--	22.97%	--

Trained as empty/Test as crowded

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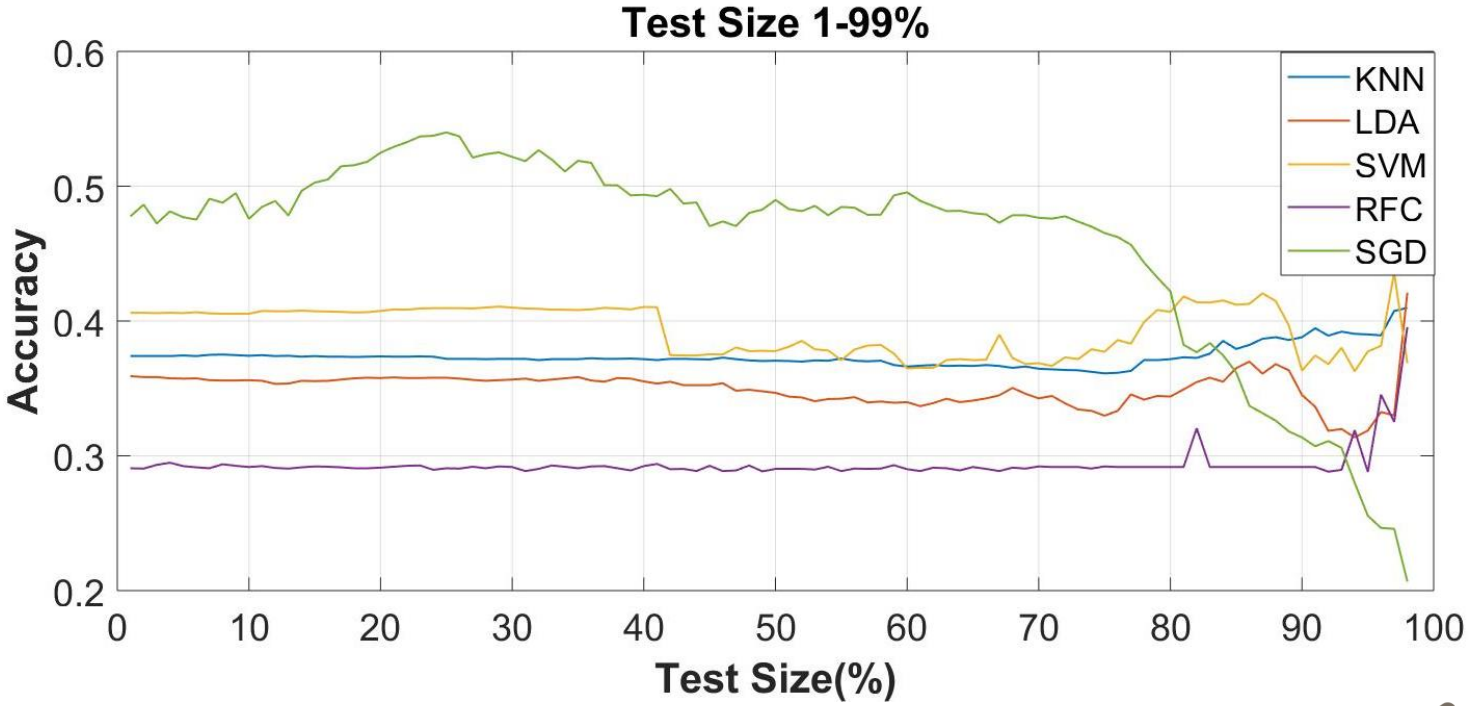
EXPERIMENTAL RESULTS CONT..

Classifier	Test size	Classification accuracy	Remarks
SGD	75%	52.23%	Loss=square_hinge random_state=4
SGD	25%	49.11%	

EXPERIMENTAL RESULTS CONT..



SUMMARY

- eNose-based localization can add a new dimension in GNSS denied areas.
- KNN classifier with Euclidian distance shows stable performance over time. However, maximum accuracy can be achieved by Stochastic Gradient Descent (SGD) classifier.
- Classification accuracy is highly dependent on the training and test data.
- Machine Learning algorithm improved localization accuracy by up to 16% from previous work.

APPLICATION AND FUTURE WORK

Application

- Can be used for localization in stagnant areas
  - Caves
  - Mines
  - Underground tunnels

Future work

- Implementation of Adaboost algorithm
- Studies of new datasets from different seasons of the year

Thank You!