**Wireless Indoor Localization**

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Github Link: <https://github.com/Hades-07/INT354>

**ABSTRACT:**

Global positioning system (GPS) is one of the most common location-based systems, but it cannot be used inside buildings as a direct line of sight (LOS) is required between the GPS receiver and the satellite to identify the user’s location. Smartphones equipped with Wi-Fi technology are widely used nowadays. Due to the need for inexpensive indoor positioning systems (IPSs), many researchers have focused on Wi-Fi-based IPSs. This paper consists of a comparison of 3 different classification algorithms k-Nearest Neighbours, Support Vector machine, Decision Trees to determine the location of a body using wireless terminals. The dataset used is the Wireless Indoor Localization from UCI. For each classification model different hyperparameters were used. Then to generate the confusion matrix, the hyperparameters with best score are used.

1. **INTRODUCTION**

Wireless indoor localization is a technology that enables the identification of the location of an object or person within an indoor environment using wireless signals such as Wi-Fi, Bluetooth, Zigbee, and Ultra-Wideband (UWB). It has become an important research area due to its potential applications in various fields such as healthcare, security, and retail. For example, it can be used in hospitals to locate patients and medical equipment. In retail stores, it can be used to track customers’ movements and provide them with personalized offers. In addition, it can be used in factories to track assets and improve workplace safety. It can also be used in museums and exhibitions to provide visitors with location-based information

Wireless indoor localization systems use existing wireless access points or wireless-enabled sensors to detect and locate transmitting wireless devices such as smartphones and tracking tags throughout indoor spaces. The system works by defining coordinates using wireless access points that can transmit certain data. Using the RSSI (received signal strength indicator) and MAC-address, the system can define exactly the current location of the user’s device using the multilateration approach.

In this paper, I aim to investigate different machine learning approaches to wireless-based indoor localization. I will provide an overview of indoor localization using wireless technologies, discuss the wireless technologies that have been used for indoor localization, compare their advantages and disadvantages as an indoor localization technology, introduce five basic machine learning models used in most literatures, summarize current trends for indoor localization and conclude the main contents of this paper.

Dataset used: <https://archive-beta.ics.uci.edu/dataset/422/wireless+indoor+localization>

1. **LITERATURE REVIEW**

**Wireless Indoor Localization Systems and Techniques: Survey and Comparative Study**

*Ahmed Azeez Khudhair, Saba Qasim Jabbar, Mohammed Qasim Sulttan, Desheng Wang*

Aug 2016-Indonesian Journal of Electrical Engineering and Computer Science-Vol. 3

A survey of the existing indoor positioning solutions and attempt to classify different its techniques and systems to have a good understanding of state of the art technologies and motivate new research efforts in this promising direction.

<https://typeset.io/papers/wireless-indoor-localization-systems-and-techniques-survey-42q8n0d7h4>

**A Review of Indoor Localization Techniques and Wireless Technologies**

*Huthaifa Obeidat, Wafa Shuaieb, Omar Obeidat & Raed Abd-Alhameed*

Wireless Personal Communications volume 119, pages289–327 (2021)

The paper starts with current localization systems and summarizes comparisons between these systems in terms of accuracy, cost, advantages, and disadvantages. Also, the paper presents different detection techniques and compare them in terms of accuracy and cost. The study contains concepts, requirements, and specifications for each category of methods presents pros and cons for investigated methods, and conducts comparisons between them.

<https://link.springer.com/article/10.1007/s11277-021-08209-5>

**A Survey of Indoor Localization Systems and Technologies**

*Faheem Zafari; Athanasios Gkelias; Kin K. Leung*

IEEE Communications Surveys & Tutorials ( Volume: 21, Issue: 3, thirdquarter 2019)

This paper primarily discusses localization and positioning of human users and their devices. We highlight the strengths of the existing systems proposed in the literature. In contrast with the existing surveys, we also evaluate different systems from the perspective of energy efficiency, availability, cost, reception range, latency, scalability, and tracking accuracy. Rather than comparing the technologies or techniques, we compare the localization systems and summarize their working principle. We also discuss remaining challenges to accurate indoor localization.

<https://ieeexplore.ieee.org/abstract/document/8692423>

**Wi-Fi indoor positioning and navigation: a cloudlet-based cloud computing approach**

*Tran Trong Khanh, VanDung Nguyen, Xuan-Qui Pham & Eui-Nam Huh*

Human-centric Computing and Information Sciences volume 10, Article number: 32 (2020)

In this paper, we propose a cloudlet-based cloud computing system enabling Wi-Fi indoor positioning and navigation through a Wi-Fi located on a one-hop wireless network. Our cloudlet-based cloud computing system provides the reference point data and real-time interactive response for a self-driving indoor cart.

<https://hcis-journal.springeropen.com/articles/10.1186/s13673-020-00236-8>

1. **PROPOSED METHODOLOGY**
2. **Data Acquisition**

The UCI Machine Learning Repository is a collection of databases, domain theories, and data generators that are used by the machine learning community for the empirical analysis of machine learning algorithms. The dataset used was collected in indoor space by observing signal strengths of seven WiFi signals visible on a smartphone. The decision variable is one of the four rooms.

1. **Data Preprocessing**

Data preprocessing is a data mining technique that involves transforming raw data into an understandable format for analysis. It involves several steps such as data cleaning, normalization, transformation, feature selection and extraction. Data cleaning involves identifying and removing missing, inconsistent, or irrelevant data. Normalization involves scaling numeric values to a common range. Transformation involves converting data from one format to another. Feature selection involves selecting a subset of relevant features for analysis. Feature extraction involves deriving new features from existing ones.

1. **Feature Selection**

The features used are signal strengths of the seven WiFi signals and the room where the smartphone is.

1. **Model Training**

Model training is a primary step in machine learning where an algorithm is fed with data to help identify and learn good values for all attributes involved. The goal of model training is to minimize the loss function over prediction range by fitting the best weights and biases to an algorithm.

1. **Model Testing**

Model testing is the process of assessing whether an ML model produces the desired outcome or not. If a model passes the tests, it is ready for deployment. However, if it fails, it must be developed and tested again.

1. **EXPERIMENTAL ANALYSIS**
2. **Evaluation parameters**

Accuracy is a well-known performance metric that is used to tell a strong classification model from one that is weak. It is simply the total proportion of observations that have been correctly predicted. For example, if you have a binary classification problem with 100 observations and your model correctly predicts 80 of them, then your accuracy would be 80%.

Accuracy can be calculated using a confusion matrix. A confusion matrix is a table that summarizes how many observations were correctly classified and how many were not. It has four entries:

True Positive (TP): The number of positive instances that were correctly classified.

False Positive (FP): The number of negative instances that were incorrectly classified as positive.

False Negative (FN): The number of positive instances that were incorrectly classified as negative.

True Negative (TN): The number of negative instances that were correctly classified.

Accuracy can be calculated as follows:

Accuracy = (TP + TN) / (TP + TN + FP + FN)

1. **Result**
   1. k-Nearest Neighbor = 0.99
   2. SVM = 0.98929
   3. Decision Tree = 0.97643

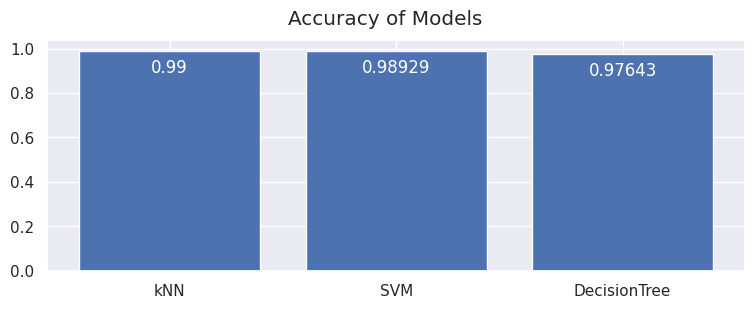


Fig 1. Accuracy of Models

1. **CONCLUSION**

The comparison of accuracy of the 3 models we implemented suggests that k-Nearest Neighbour is the best model for wireless indoor localization using Wi-Fi. However, this result is not applicable in every implementation of indoor localization. Other methods like BLE may require different models. Further research into these methods could greatly improve many aspects of our everyday life.

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