Bike Sharing:
Dissertation Report

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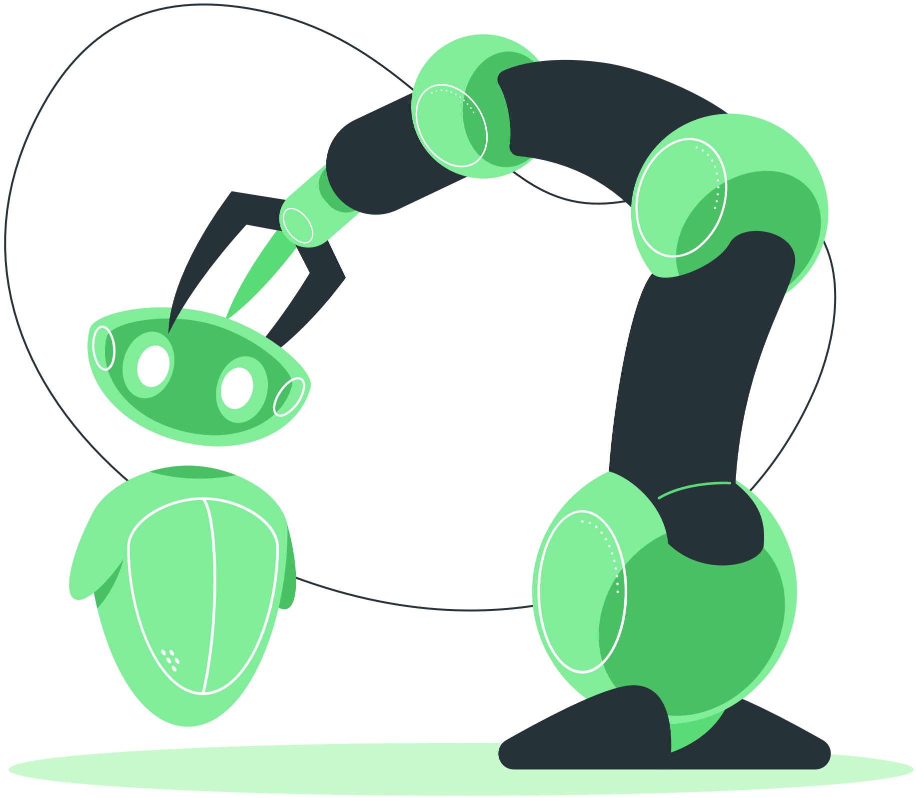


Report Outline

1 Introduction

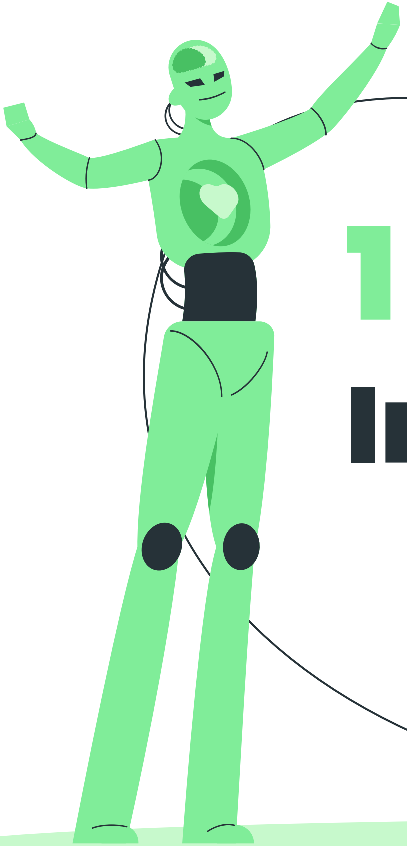
2 Search and Screening Methodology

3 Literature Review

4 Preliminary Work

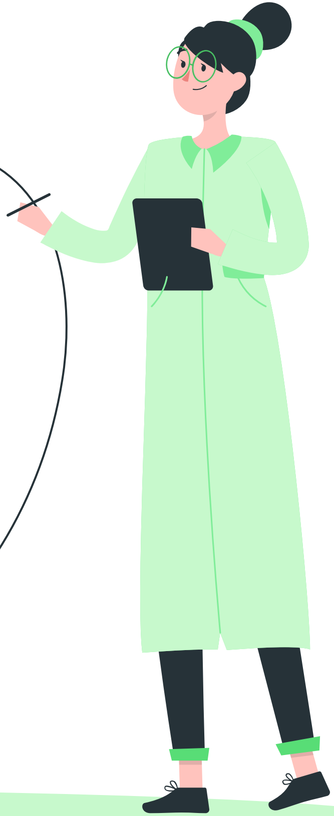
5 Work Plan

6 Conclusion



1

Introduction



Motivation

Bike sharing is the shared use of a bicycle fleet;

There are many benefits on the use of a bike sharing system (BSS), like enhanced mobility, and reduced traffic congestion, fuel consumption and greenhouse gas emissions;

There are two types of BSSs:

- Standard BSSs - users rent a bike from a docking station and return it to another
- Dockless BSSs - bikes can be found and parked anywhere

Many problems also arise, like theft, vandalism and the reallocation of bikes;

The literature divides the last problem in two categories:

- Bike Repositioning Problem (BRP)
- Demand Prediction (DP)

Objectives

1

Compare different machine and deep learning models

Choose the most suitable model for the prediction of available bikes

2

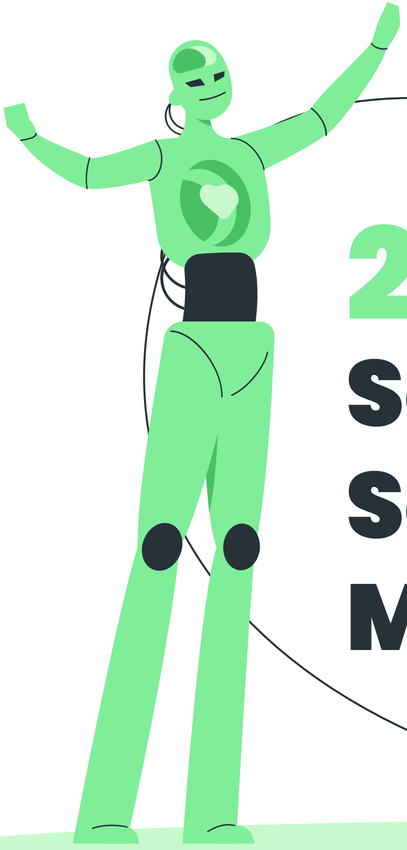
Build, train and test the model

Create the most efficient model while comparing to state of the art models

3

Implement the model in diverse applications

Introduce the results in a mobile and a redistribution applications



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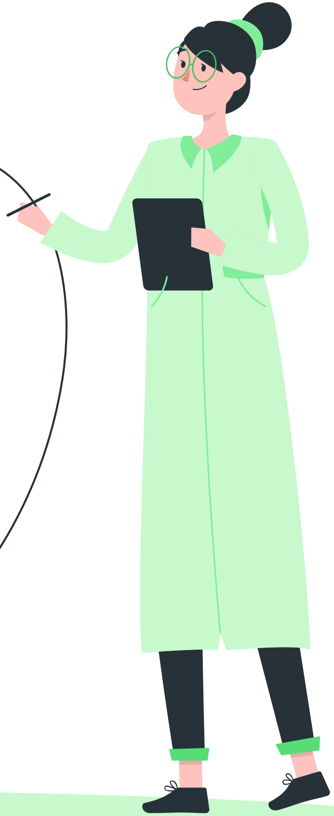
Search and Screening Methodology



Methodology

Complete Search

Search based on all the literature

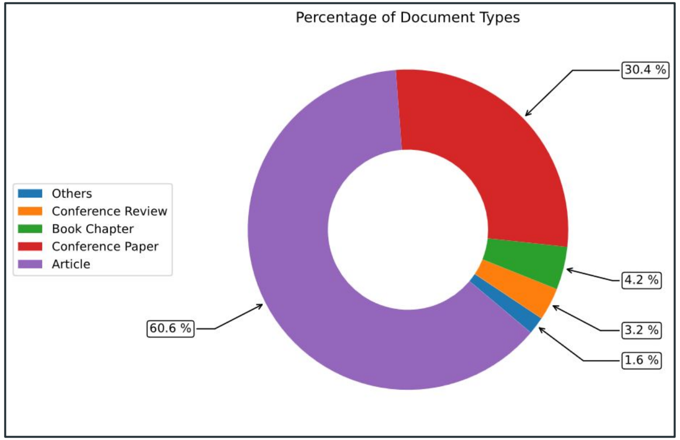
Advanced Search

Search with more specific parameters

Screening Process

Check the resulting papers by relevance

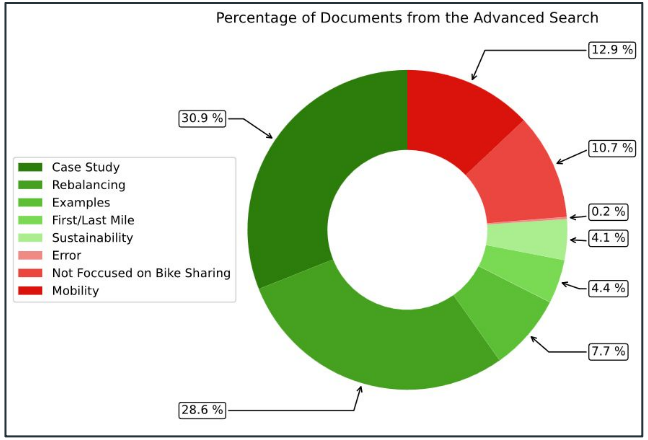
Complete Search



TITLE-ABS-KEY (bike-sharing OR bikesharing OR “bike sharing”) AND LANGUAGE (english) AND PUBYEAR < 2025

Resulting in 2,738 papers

Advanced Search



TITLE-ABS-KEY (bike-sharing OR bikesharing OR “bike sharing”) AND SRCTYPE (j) AND LANGUAGE (english) AND PUBYEAR < 2025

Resulting in 1,800 papers

1,316 Included Papers

Inclusion Themes

Case Study: Studies on the impacts, problems, etc, and analysis of different types of BSSs.

Rebalancing: Studies on prediction models and algorithms for BSSs.

Examples: Studies on BSSs in a specific city, of their failure or success.

First/Last Mile: Studies on the correlation between BSSs and any transportation method.

Sustainability: Studies on the green impact of BSSs.

Excluded Conditions

Mobility: Studies on mobility as a service problems and mobility sharing.

Not Focused on Bike Sharing: Studies that use BSSs as an example or use data from a BSS.

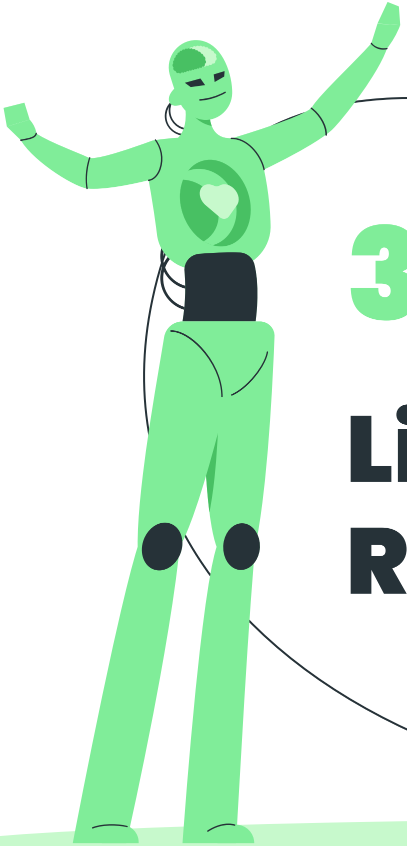
Error: Any Erratum study.

Screening Process

Impact of the

$$impact = \frac{number\_of\_citations}{number\_of\_years\_since\_publication}$$

500 Selected Papers



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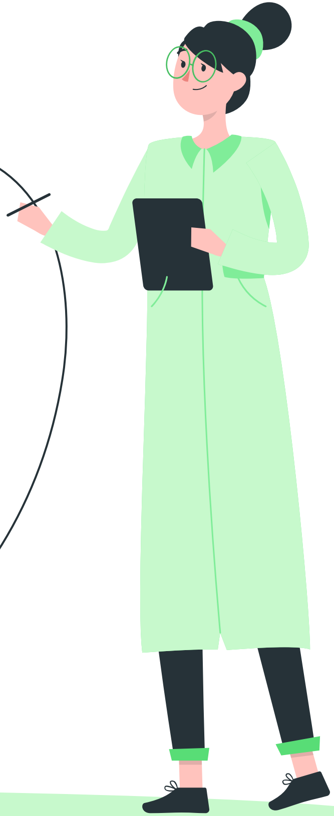
Literature Review



Generations

1

White Bikes

Introduced in Amsterdam
1965-1994

2

Coin-Deposit

Introduced in Copenhagen
1995-1997

3

IT-Based

Introduced in Rennes
1998-2009

4

Demand-Responsive

2009-2015

5

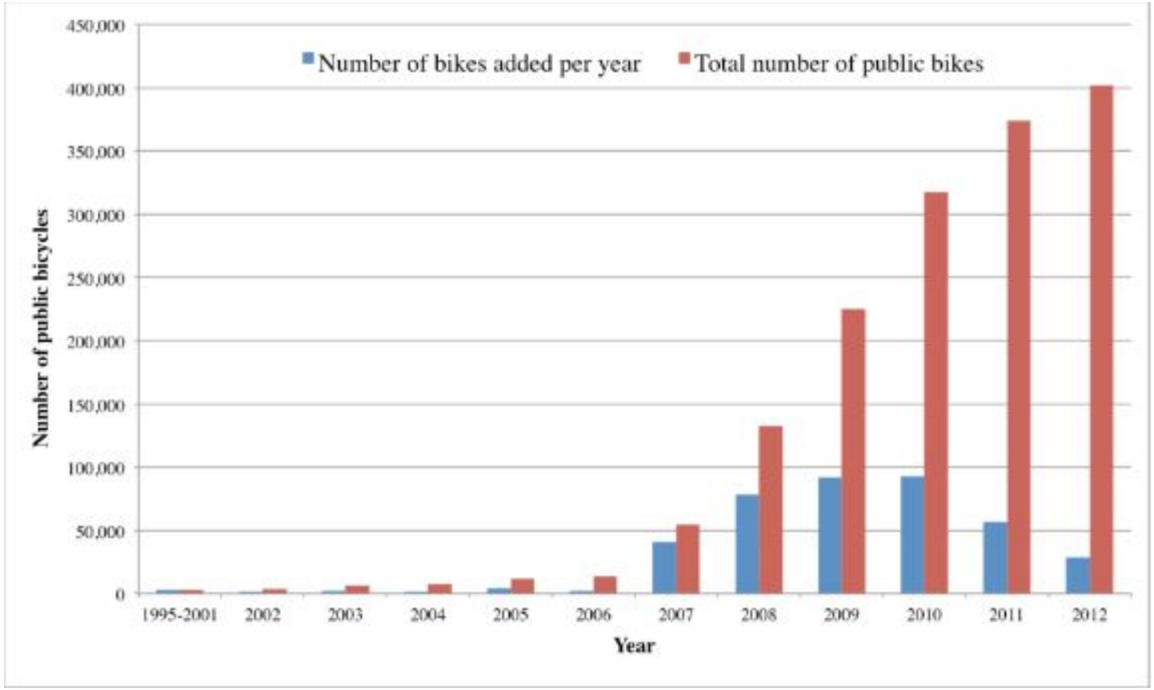
Dockless

2016-Present

Generations

White Bikes	Coin-Deposit	IT-Based	Demand	Dockless
Free bikes	Unlocked with a coin	Innovative technologies	Electric bikes	Bikes can be parked anywhere
Bikes randomly parked	Docking stations	Bikes with locks	More efficient stations and a redistribution system	Easier for a user to pick up or drop off a bike
Bikes thrown into channels and stolen	Continued theft and vandalism	Anti-theft program	GPS to reduce theft and vandalism	A reallocation team is to gather all randomly parked bikes into different areas

Evolution – Until 2012



Parked Bikes Problem

In Dockless BSSs

Repositioning randomly parked bikes into different areas

Bike Repositioning Problem

Calculation of ideal truck routes at each station

In Standard BSSs

Relocating existing or new bikes into stations

Demand Prediction

Prediction of the number of bikes left in a station at a certain point in time

Demand Prediction

1

City-Level

Focused on predicting the total bike usage for an entire city

Doesn’t utilize all available data

2

Cluster-Level

Focused on grouping stations into clusters

Clusters based on geographical locations or temporal demand patterns

3

Station-Level

Focused on predicting demand for each station

Much more challenging to implement

Demand Prediction Models

	Name	# Papers	Metrics
LSTM	Long Short-Term Memory	11	RMSE, MAE, MAPE, MSE, PCC, SMAPE
ARIMA	Autoregressive Integrated Moving Average	11	RMSE, MAE, MAPE, R^2, RMSER, MAER, RMSLE, ER
HA	Historical Average	9	RMSE, MAE, MAPE, R^2, PCC, RMSLE, ER
RF	Random Forest Algorithm	9	RMSE, MAE, R^2, CV, MAE, RMSE, RMSLE
LR	Linear Regression	9	RMSE, MAE, R^2, CV, RMSER, MAER

Demand Prediction Models

	Name	# Papers	Metrics
XGBoost	Extreme Gradient Boosting	6	RMSE, MAE, MAPE, PCC
KNN	K-Nearest Neighbours	5	RMSE, MAE, MAPE, R^2
SVM	Support Vector Machine	5	RMSE, MAE, MAPE, R^2, CV
ANN	Artificial Neural Network	4	RMSE, MAE, MAPE, MAE, RMSE, RMSLE
RNN	Recurrent Neural Network	4	RMSE, MAE, MAPE, R^2, PCC, SMAPE, MSE

Models

ANN

One of the most common, but doesn't account for temporal dependencies

RNN

Can overcome the Limitation, but it is still not fit for the time series data

LSTM

Solves the Problem, can be used with neural networks and different layers

SVM

Developed to seek the finest hyperplane classification of data

ARIMA

Commonly used for forecasting time series, applied in traffic prediction

HA

Uses historical average data for prediction

RF

Used to overcome the problem of a model having large amount of predictors

LR

The simplest model, taking one or more input features, and outputting one value

XGBoost

Based on gradient boosted decision tree

KNN

Predicts based on it's K closes neighbours

Metrics

MSE and RMSE

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(x_i - y_i)^2$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - y_i)^2}$$

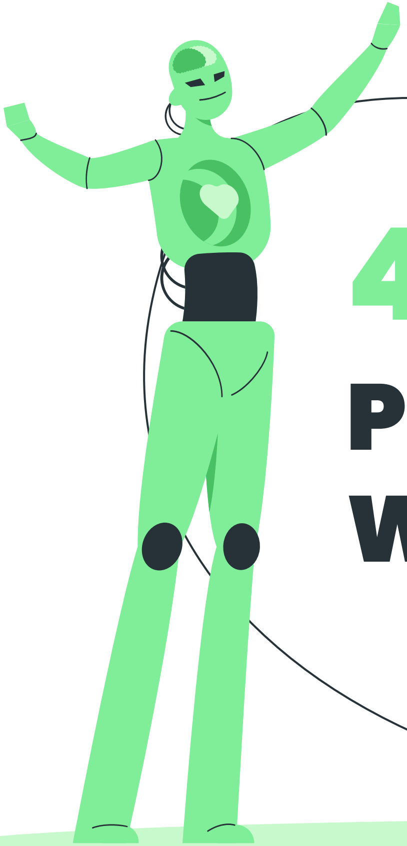
Mostly applied when large errors must be penalized

MAE and MAPE

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|x_i - y_i|$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}|\frac{x_i - y_i}{x_i}| \times 100$$

Used when all the errors are treated equally



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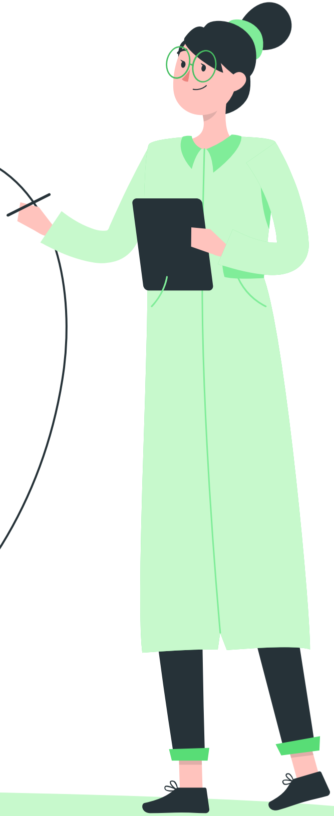
Preliminary Work



Scripting

1

Automatic Translation

Translated the downloaded scopus text file into a .csv data file

2

Manual Selection

Select papers to include or exclude in the screening process

3

Screening Search

Search mechanism based on title or theme

Infrastructure

BSSs incorporate more than just bikes, stations, trucks and demand prediction models.

The Infrastructure:

- Dashboards with various information on bikes, stations, users, trips, etc.
- Communicating bikes suggest a service oriented architecture
- Database to save all the information, including the messages exchanged
- Mobile application for the user to rent a bike
- Reallocation application for the redistributor to know where to load and unload the bikes

Data

Data sourced from an in development system, based on the trip data

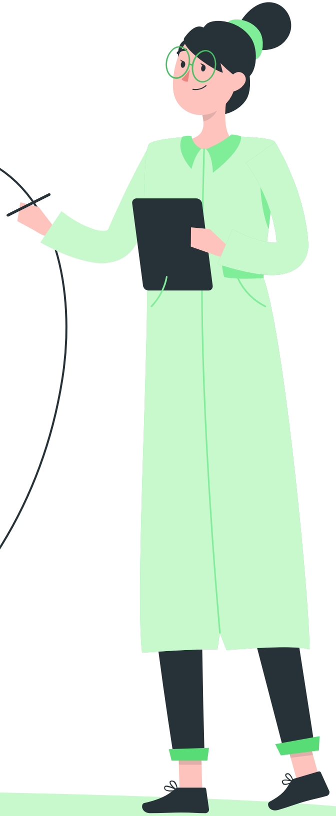
A trip is divided into three operations:

- Unlocking a bike: bike sends message to the system, which then responds with confirmation or denial
- Starting the trip: bike sends starting the trip message when the bike is pulled from the station
- Locking the bike: bike sends lock message to the system to inform that the bike is locked

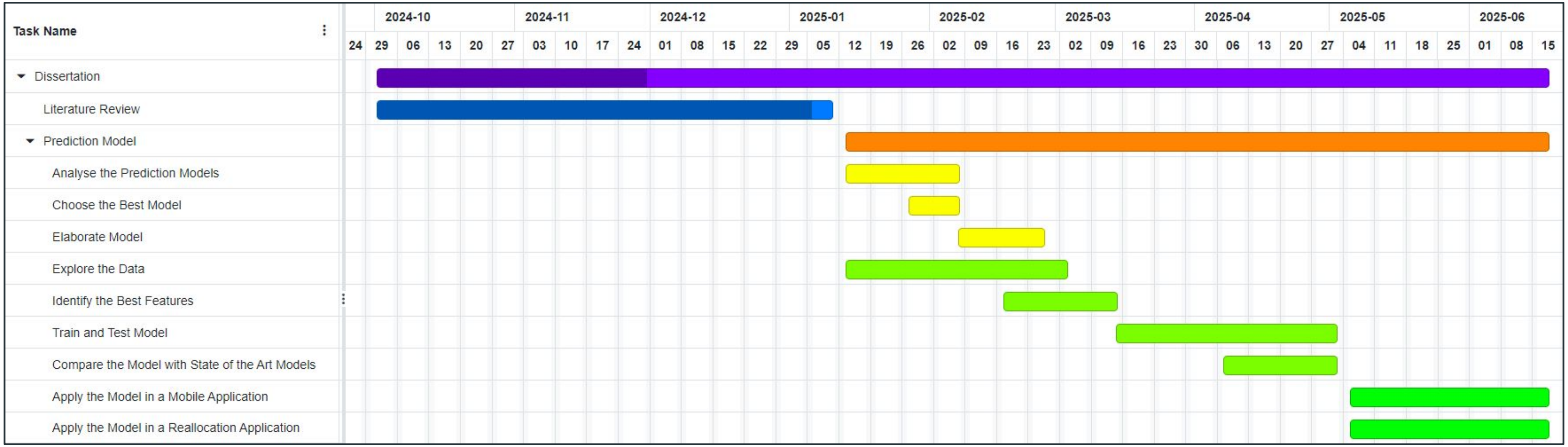
We can deduce start station, end station, trip duration, etc.

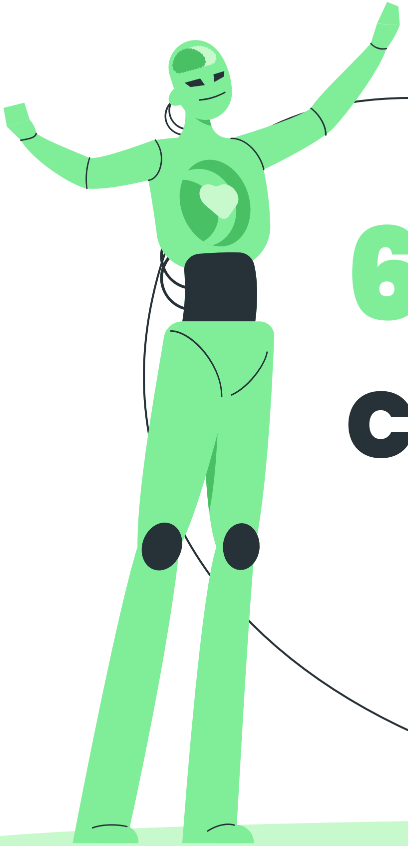
5

Work Plan



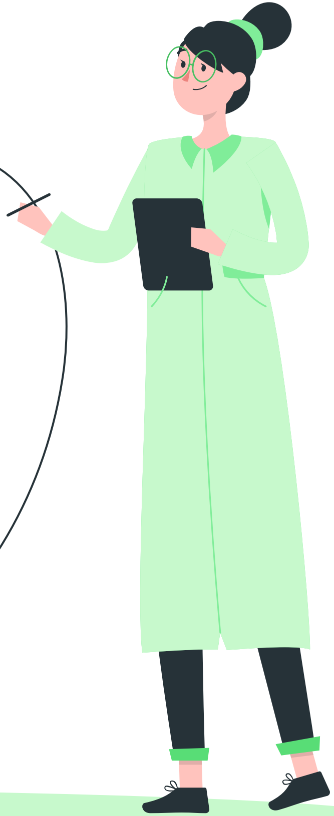
Gantt Chart


Task Name
2024-10
2024-11
2024-12
2025-01
2025-02
2025-03
2025-04
2025-05
2025-06
24 29 06 13 20 27 03 10 17 24 01 08 15 22 29 05 12 19 26 02 09 16 23 02 09 16 23 30 06 13 20 27 04 11 18 25 01 08 15
Dissertation
Literature Review
Prediction Model
Analyse the Prediction Models
Choose the Best Model
Elaborate Model
Explore the Data
Identify the Best Features
Train and Test Model
Compare the Model with State of the Art Models
Apply the Model in a Mobile Application
Apply the Model in a Reallocation Application



6

Conclusion



Summary

Screening Process

From 2700 searched to 500 screened papers

Literature Review

Five generations of BSSs were devised and studied

Reallocation Problem

Divided into two different categories: BRP and DP

Infrastructure

Dashboards, database, architecture and apps

Thanks!

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