Borsa di studio attivata ai sensi di quanto disposto dal D.M. n. 1061 del 10/08/2021

Titolo del progetto: Online transport mode detection via machine and deep learning models

La borsa sarà attivata sul seguente corso di dottorato accreditato per il XXXVII ciclo:
INFRASTRUTTURE E TRASPORTI

Responsabile scientifico: Guido Gentile
Area per la quale si presenta la richiesta: GREEN
Numero di mensilità da svolgere in azienda: 12
Numero di mensilità da svolgere all'estero: 6 presso Università del Lussemburgo
Azienda: Movesion srl
Il Dipartimento è disponibile a cofinanziare per un importo pari a euro: 10000
Dipartimento finanziatore: DIPARTIMENTO DI INGEGNERIA CIVILE, EDILE E AMBIENTALE con delibera del 22.09.2021

Progetto di ricerca:
Abstract
Today's mobile devices are packed with nearly 14 sensors that produce raw data on motion, location and the environment around people. Attempts have been made to automatically distract transit modes from the embedded sensors of mobile phones to significantly reduce the cost in time and budget of conventional travel diary surveys. Moreover, detecting users' transportation modes is a vital phase towards many transportations related difficulties such as transport planning and managing, transit demand investigation, and transportation emissions studies. A conceivable solution to identify transport mode detection with the data extracted by mobile phones is by using deep learning frameworks that are computationally able of capturing abstract features from the raw input data. The objective of this PhD research project is to develop deep and machine learning models to detect urban transit modes and mode choice with low number of sensors and extracting new indicators of people's behavior such as total waiting time and access time of users to the public transport that they can be used to optimize our urban network infrastructure.
Keywords: deep learning models, transport mode detection, urban trips, mode choice

1 Introduction
Transportation is one of the principal elements of any civilization which has a direct impact on the quality of life of the inhabitants. For any journey from origin to destination, travelers should choose at least one transportation facility, which is divided into two major groups: Motorized like a car, bus, or train, and non-Motorized like a bicycle or walking. Moreover, the database of the travel mode selection has conventionally been obtained manually by questionnaires and phone interviews. However, this method requires a substantial amount of time and energy. Over recent years, the applications of machine and deep learning techniques have conquered diverse fields of technology, one of which is the classification of the commuter's transportation mode on the bases of smartphones' sensors. It is clear that detection each part of urban trips including which transit mode was used by user can lead to understanding better people's behavior in urban travel in order to optimize infrastructure.

1.1 Research problem
Traditionally, the data for analyzing passengers' habits for deciding transport modes was collected via travel surveys. The main problem of this approach can be high cost, low-response rate, time- consuming, manual data collection, and

misreporting. Another point is that municipalities are seeking to find a way to monitor online how much is the online demand for each mode of transport in each urban zone. Therefore, travel surveys and questionnaire are not able to give transport planners these vital data online and precisely.

1.2 Scope of research

The main idea of this project is to find innovative solutions for measuring and detecting main transit modes via deep and machine learning models and defining new indicators of urban trips.

1.3 Main research question

How to detect the most common transit modes on the cities and what indicators we can extract from the results of transport modes are the main research question of this great proposal.

2 Literature review

Today's mobile devices are packed with nearly 14 sensors that produce raw data on motion, location and the environment around people. One of the initial analyses of motion classification has been done based on microcontroller accelerometer sensor for making valuable knowledge about the user's situation (whether the traveler is biking, standing still, walking, running, etc.). After the early twentieth century, with the technological development of mobile phones, almost all of the studies for detecting of user's transportation mode focused on sensors that are embedded on mobile phones. Investigation on the identification of commuter's transport mode has carried out based on the Global System for Mobile (GSM) sensor of the cellphones Eventually, they reached 80 percent of accuracy just with three various labels . Furthermore, they proved that for detecting the mode of transport, GSM signals are not adequate. In the following years, the advancement in the field of GPS influenced not only monitoring commuters' trajectories but also detecting their modality of mobility in a positive direction. Accordingly, in this work they presented a liberal approach to recognize four distinctive modes (biking, driving, taking a bus, walking) with 72.8 percent inference accuracy using just GPS data. To the best of my knowledge, deep learning has emerged in transportation applications since 2014. For the first time in this study, they demonstrated that deep learning approaches can achieve higher performance accuracy for predicting traffic flow, compared to the existing state-of-the-art. Several travel mode detection techniques, that use deep learning algorithms, have been proposed during the last decade and most of them use classical deep learning architectures such as Convolutional Neural Networks. One of the investigations to detect 5 modes of transport used deep learning models (CNN). They propose to use the convolutional neural network (CNN) for inferring transportation modes based on raw GPS trajectories. They can distinguish five different instances as walk, bicycle, bus, driving, and train with the final test accuracy of 84.8 percent. In another work, prediction mode of transport with just using accelerometer has been used . They found that CNN can achieve an accuracy of 94.48% and among all the traditional methods, random forest performs the best in accuracy by assembling multiple decision trees and different features. One of the biggest investigations has been tested via deep learning models. 1000 hours of accelerometer, magnetometer and gyroscope data applied from five transportation modes including still, walk, run, bike, and vehicle. Experimental results confirm the effectiveness of the proposed mechanism, which achieves approximately 95% classification accuracy and outperforms four well-known machine learning methods. The results shows that the performance of deep learning models is better than traditional machine learning models. Furthermore, new algorithm to detect modes of transport is RNN . Recurrent Neural Networks to predict four modes of transport was applied and achieved over 98% and 97% classification accuracy when detecting 4 and 7 types of transportation modes. All above studies tried to detect transport mode detection while extracting new indicators of urban trips after mode detection can be more worthwhile.

2.1 Constraints of existing methodologies:

There are some limitations as below:

• According to the literature, most of the studies just detect some categories of transit mode while most of the mobile phones are not equipped with rich set of sensors.

• Studies usually use machine learning models to detect mode of transport whereas deep learning models practically are more powerful and precise.

• The most important constrain is that detection mode of transport cannot be enough and most of the studies at the

literature have just done recognizing which mode of transport people have used while we are able to define and extract new indicators of the urban trips.

3 Research Objectives

The final objectives of this research are categorized into two main phases. The first one is that recognizing 8 common urban mode of transport in the cities via new and novel deep learning algorithms with the low set of sensors. In addition, implementing android application in order to test the results of the project into the reality and comparison with google API. The second phase of the final project is to extract rich information of passenger's trips. We know that each urban trip is included by several trajectories, after detecting the modes of each trajectory, we are able to compute new indicators of whole trips. There are some new elements of each trip that we compute through deep learning models for the first time. For example: 1. How much is the waiting time of users at each specific bus or metro station (waiting time is the standing time before getting bus and metro) 2.How much is the access time to the public transport (bus, metro and tram) for each user with specific GPS location 3. The time that people are in their private cars and public transport (metro and bus) that can be used for online traffic monitoring distance.

Titolo del progetto (inglese): Online transport mode detection via machine and deep learning models

Progetto di ricerca (inglese):

Abstract

Today's mobile devices are packed with nearly 14 sensors that produce raw data on motion, location and the environment around people. Attempts have been made to automatically distract transit modes from the embedded sensors of mobile phones to significantly reduce the cost in time and budget of conventional travel diary surveys. Moreover, detecting users' transportation modes is a vital phase towards many transportations related difficulties such as transport planning and managing, transit demand investigation, and transportation emissions studies. A conceivable solution to identify transport mode detection with the data extracted by mobile phones is by using deep learning frameworks that are computationally able of capturing abstract features from the raw input data. The objective of this PhD research project is to develop deep and machine learning models to detect urban transit modes and mode choice with low number of sensors and extracting new indicators of people's behavior such as total waiting time and access time of users to the public transport that they can be used to optimize our urban network infrastructure.

Keywords: deep learning models, transport mode detection, urban trips, mode choice

1 Introduction

Transportation is one of the principal elements of any civilization which has a direct impact on the quality of life of the inhabitants. For any journey from origin to destination, travelers should choose at least one transportation facility, which is divided into two major groups: Motorized like a car, bus, or train, and non-Motorized like a bicycle or walking. Moreover, the database of the travel mode selection has conventionally been obtained manually by questionnaires and phone interviews. However, this method requires a substantial amount of time and energy. Over recent years, the applications of machine and deep learning techniques have conquered diverse fields of technology, one of which is the classification of the commuter's transportation mode on the bases of smartphones' sensors. It is clear that detection each part of urban trips including which transit mode was used by user can lead to understanding better people's behavior in urban travel in order to optimize infrastructure.

1.1 Research problem

Traditionally, the data for analyzing passengers' habits for deciding transport modes was collected via travel surveys. The main problem of this approach can be high cost, low-response rate, time- consuming, manual data collection, and misreporting. Another point is that municipalities are seeking to find a way to monitor online how much is the online demand for each mode of transport in each urban zone. Therefore, travel surveys and questionnaire are not able to give transport planners these vital data online and precisely.

1.2 Scope of research

The main idea of this project is to find innovative solutions for measuring and detecting main transit modes via deep and machine learning models and defining new indicators of urban trips.

1.3 Main research question

How to detect the most common transit modes on the cities and what indicators we can extract from the results of transport modes are the main research question of this great proposal.

2 Literature review

Today's mobile devices are packed with nearly 14 sensors that produce raw data on motion, location and the environment around people. One of the initial analyses of motion classification has been done based on microcontroller accelerometer sensor for making valuable knowledge about the user's situation (whether the traveler is biking, standing still, walking, running, etc.). After the early twentieth century, with the technological development of mobile phones, almost all of the studies for detecting of user's transportation mode focused on sensors that are embedded on mobile phones. Investigation on the identification of commuter's transport mode has carried out based on the Global System for Mobile (GSM) sensor of the cellphones Eventually, they reached 80 percent of accuracy just with three various labels . Furthermore, they proved that for detecting the mode of transport, GSM signals are not adequate. In the following years, the advancement in the field of GPS influenced not only monitoring commuters' trajectories but also detecting their modality of mobility in a positive direction. Accordingly, in this work they presented a liberal approach to recognize four distinctive modes (biking, driving, taking a bus, walking) with 72.8 percent inference accuracy using just GPS data. To the best of my knowledge, deep learning has emerged in transportation applications since 2014. For the first time in this study, they demonstrated that deep learning approaches can achieve higher performance accuracy for predicting traffic flow, compared to the existing state-of-the-art. Several travel mode detection techniques, that use deep learning algorithms, have been proposed during the last decade and most of them use classical deep learning architectures such as Convolutional Neural Networks. One of the investigations to detect 5 modes of transport used deep learning models (CNN). They propose to use the convolutional neural network (CNN) for inferring transportation modes based on raw GPS trajectories. They can distinguish five different instances as walk, bicycle, bus, driving, and train with the final test accuracy of 84.8 percent. In another work, prediction mode of transport with just using accelerometer has been used . They found that CNN can achieve an accuracy of 94.48% and among all the traditional methods, random forest performs the best in accuracy by assembling multiple decision trees and different features. One of the biggest investigations has been tested via deep learning models. 1000 hours of accelerometer, magnetometer and gyroscope data applied from five transportation modes including still, walk, run, bike, and vehicle. Experimental results confirm the effectiveness of the proposed mechanism, which achieves approximately 95% classification accuracy and outperforms four well-known machine learning methods. The results shows that the performance of deep learning models is better than traditional machine learning models. Furthermore, new algorithm to detect modes of transport is RNN . Recurrent Neural Networks to predict four modes of transport was applied and achieved over 98% and 97% classification accuracy when detecting 4 and 7 types of transportation modes. All above studies tried to detect transport mode detection while extracting new indicators of urban trips after mode detection can be more worthwhile.

2.1 Constraints of existing methodologies:

There are some limitations as below:

• According to the literature, most of the studies just detect some categories of transit mode while most of the mobile phones are not equipped with rich set of sensors.

• Studies usually use machine learning models to detect mode of transport whereas deep learning models practically are more powerful and precise.

• The most important constrain is that detection mode of transport cannot be enough and most of the studies at the literature have just done recognizing which mode of transport people have used while we are able to define and extract new indicators of the urban trips.

3 Research Objectives

The final objectives of this research are categorized into two main phases. The first one is that recognizing 8 common urban mode of transport in the cities via new and novel deep learning algorithms with the low set of sensors. In addition, implementing android application in order to test the results of the project into the reality and comparison with google API. The second phase of the final project is to extract rich information of passenger's trips. We know that each urban trip is included by several trajectories, after detecting the modes of each trajectory, we are able to compute new indicators of whole trips. There are some new elements of each trip that we compute through deep learning models for the first time. For example: 1. How much is the waiting time of users at each specific bus or metro station (waiting time is the standing time before getting bus and metro) 2.How much is the access time to the public transport (bus, metro and tram) for each user with specific GPS location 3. The time that people are in their private cars and public transport (metro and bus) that can be used for online traffic monitoring distance.