10th Brazilian Conference on Intelligent Systems (BRACIS)

Fast Movelet Extraction and Dimensionality Reduction for Robust Multiple Aspect Trajectory Classification

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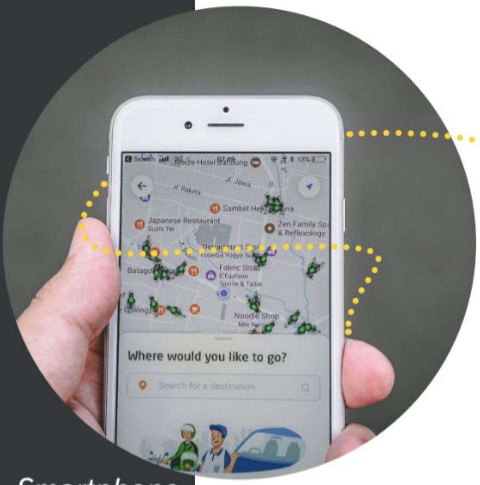
CAPES

This work has been partially supported by the Brazilian agencies CAPES, CNPQ and FAPESC.

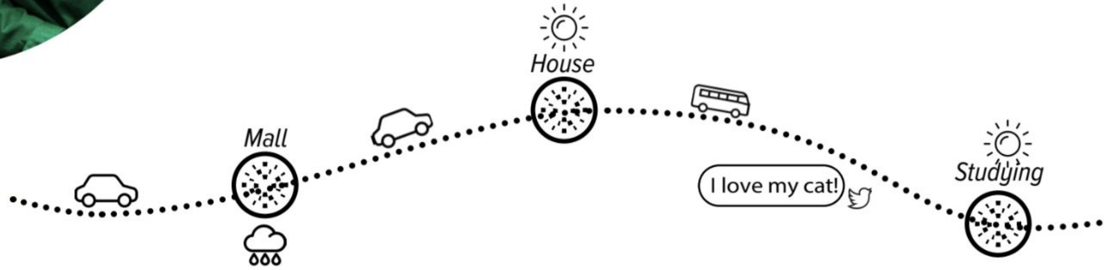
INTRODUCTION
Context



Smartphone Application

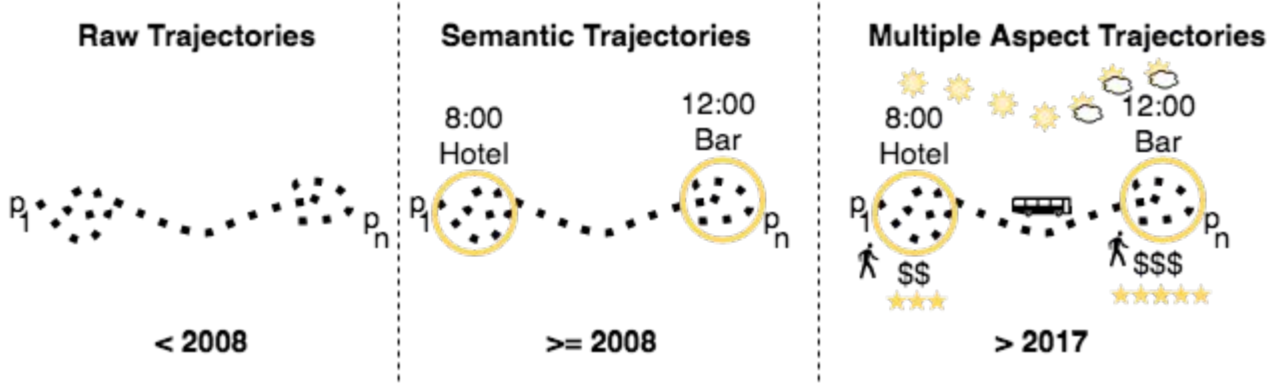
Popularization and price reduction of mobile devices

- Large volumes of mobility data;
- **Big Data.**



INTRODUCTION

Trajectory



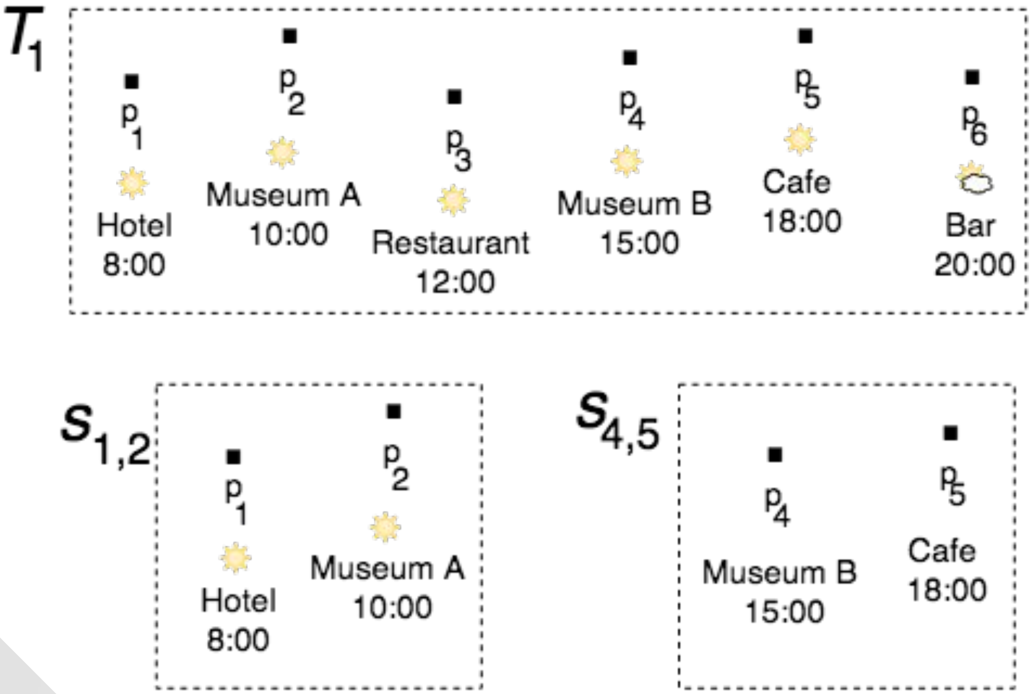
→ A **Multiple Aspect Trajectory** T_i is a sequence of *m* elements $T_i = \langle e_1, e_2, ..., e_m \rangle$, where each element is characterized by a set of *l* dimensions $D = \{ d_1, d_2, ..., d_l \}$, also called aspects.

→ Multiple and heterogeneous dimensions.

[Ferrero et al., 2016; Mello et al., 2019]

INTRODUCTION:

Trajectory and Subtrajectory



But,
What is a movelet?

Inspired by time series shapelet [Ye, L.; Keogh, E., 2011] a movelet is a subtrajectory that used by a classifier, better discriminate a class

INTRODUCTION

Trajectory Classification

- Trajectory data mining is important for discovering interesting knowledge and behavior about different objects as people, animals, vehicles, weather condition;

- An important data mining technique is classification:

Trajectory classification is the task of discovering the class label of a moving object based on its trajectories (Lee et al.2008).

INTRODUCTION

Motivation

Applications of Trajectory Classification

a. Transportation mean classification;
b. The strength level of a hurricane / Natural disaster prediction;
c. The type of a vessel;
d. Animal categories
e. The moving object, owner of the trajectory.

RELATED WORKS
Trajectory Classification

1st Semantic Classification
(TRAGOPOULOU; VARLAMIS;EIRINAKI, **2014**)
(VARLAMIS, **2015**)

Transportation Mean
(XIAO et al., **2017**)
(ETEMAD; SOARES JÚNIOR; MATWIN, **2018**)
(DABIRI; HEASLIP, **2018**)

General
(SANTOS; JR; ALVARES, **2011**)

***Survey* ***
(LEITE DA SILVA; MAY PETRY; BOGORNY, **2019**)

POI-F
(VICENZI et al., **2020**)

***Deals with multiple dimensions**

Movelets
(FERRERO et al., **2018**)

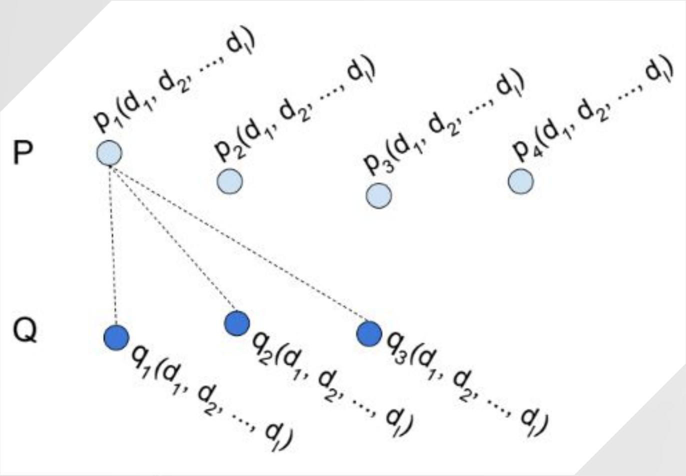
MASTERMovelets
(FERRERO et al., **2020**)

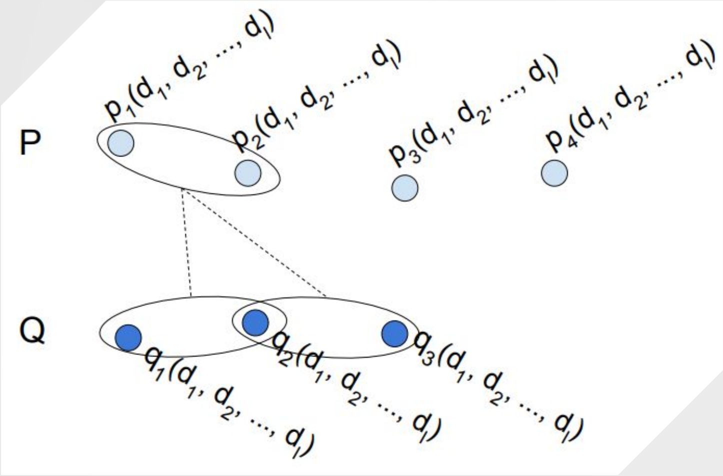
MARC
(MAY PETRY et al., **2020**)

RELATED WORKS

Movelets and MASTERMovelets

- Parameter free;
- Analyze every possible subtrajectory and computes the distance of all subtrajectories of the same size in the dataset.





RELATED WORKS

MASTERMovelets Method Overview

1. Computes element distances (point-to-point)
2. Extracts all subtrajectories with any subset of dimensions (movelet candidates)
3. For each candidate, compares to all trajectories:
    a. Find the **best alignment** (in each position of a trajectory)
    b. Evaluates the F-Score (split the classes)
4. Select the best movelets

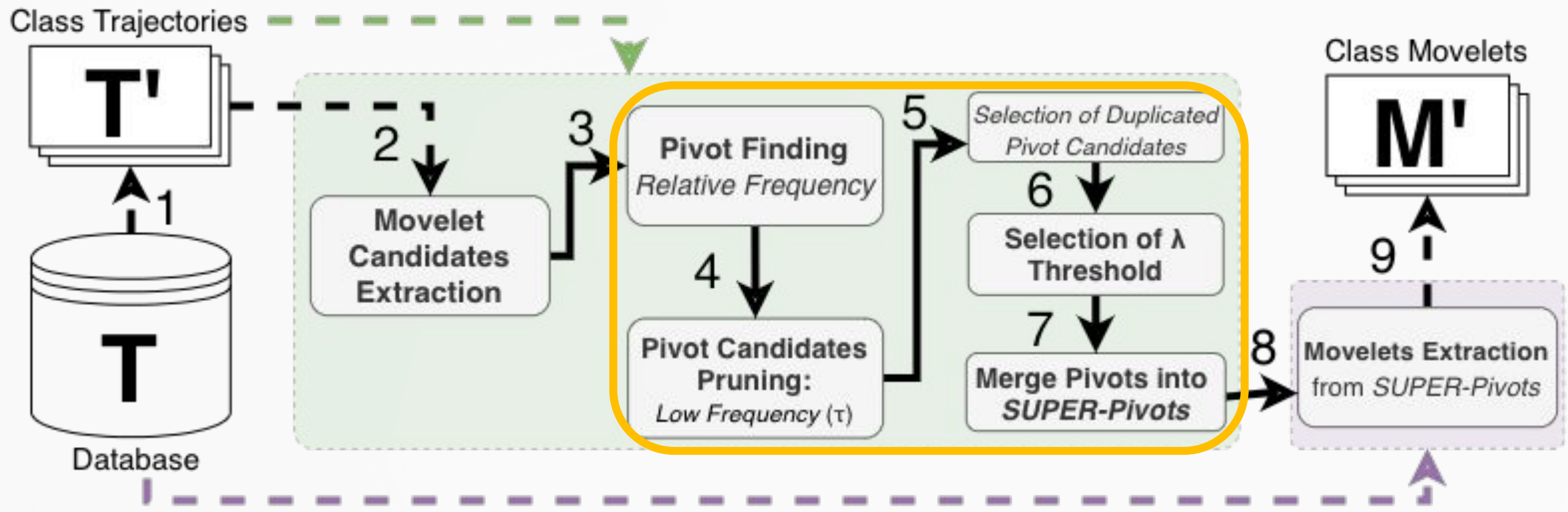
PROBLEM DEFINITION

- The problem of trajectory classification relies on finding the best ***trajectory*** or ***subtrajectory*** features to use as input to a classifier [Ferrero te al., 2020];
- Related works do not propose new classifiers (RF, NN, DT)
- So far, movelets [Ferrero te al., 2019] has been one of the best approaches:
  - highest accuracy
  - general problems
  - Interpretable patterns;

- **Problem**:
  - Movelets extraction is very time consuming.

PROPOSAL

SUPERMovelets



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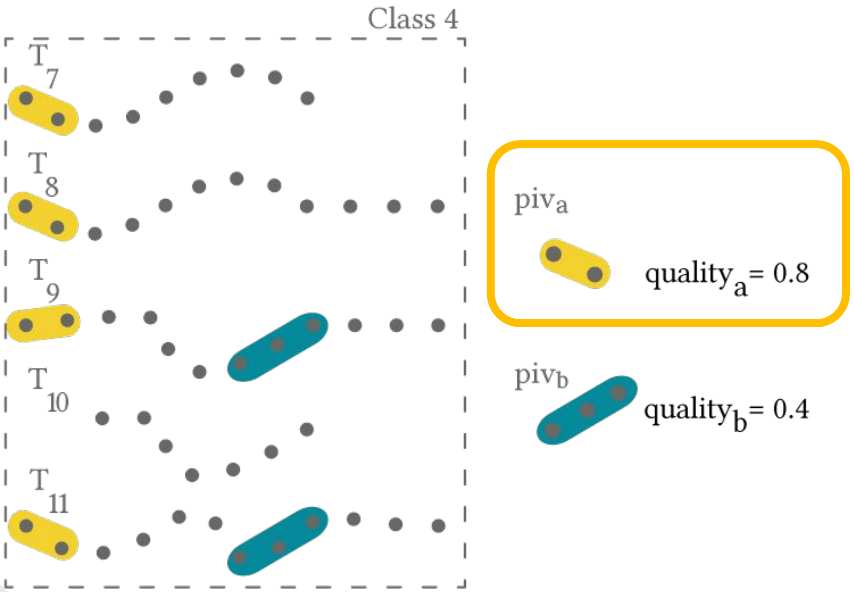
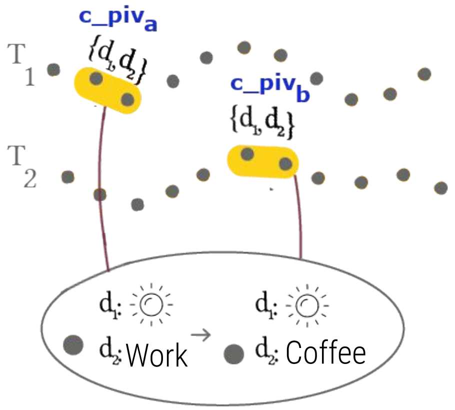
PROPOSAL

SUPERMovelets

Search space is reduced by the SUPER-Pivots:

- **Quality proportion** of the pivot candidates;
- **Redundant** pivot candidates (same size and trajectory dimensions).





EXPERIMENTAL RESULTS

Highlights

- **SUPERMovelets movelet extraction:**
  - Movelet extraction 50-94% faster than MASTERMovelets;
- **SUPERMovelets accuracy:**
  - Same accuracy as MASTERMovelets (less than 1% difference);
  - Generates significantly less movelets (65-93% reduction);
  - Faster to build classification models.

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THANK YOU

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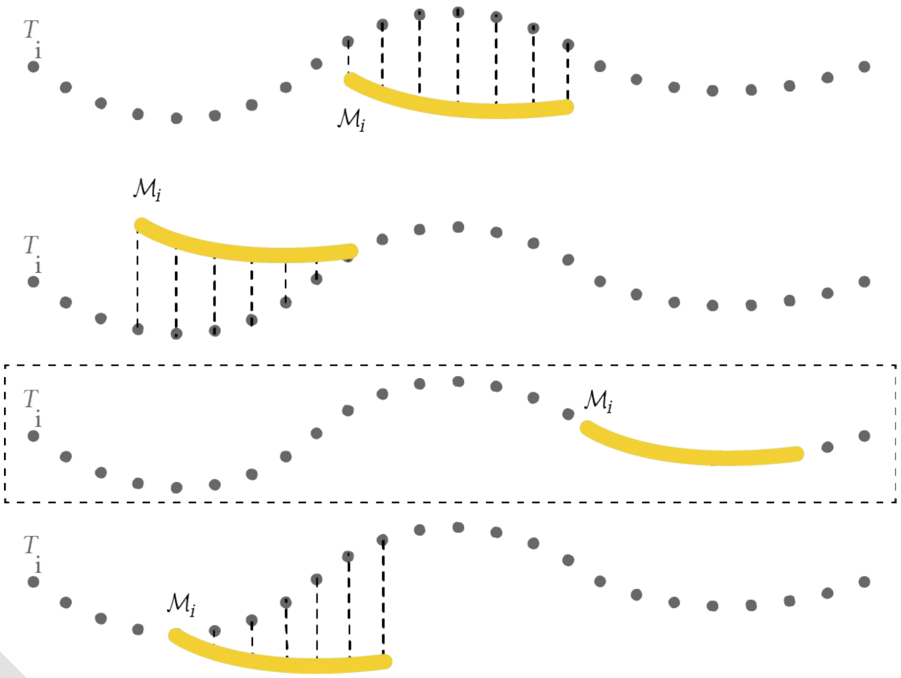
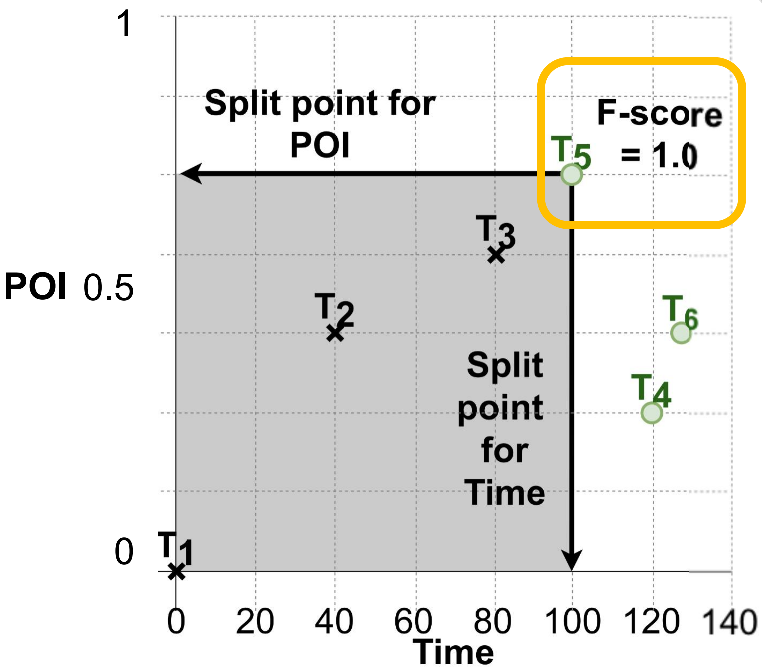
BASIC CONCEPTS

Finding the Best Alignment





BASIC CONCEPTS

MASTERMovelets Complexity

- **n** → the number of trajectories;
- **m** → the length of the longest trajectory, and;
- **l** → the number of dimensions of the dataset

Space: it stores at most n × m candidates for all trajectories.

$O(n \times m^2 \times l)$ → *Matrix of Distances* *

Running Time: the overall time complexity is

$O(n^3 \times m^3 \log m \times 2^l)$

EXPERIMENTAL RESULTS

Scalability: Number of Dimensions

All experiments: faster as dimensions are added

EXPERIMENTAL RESULTS

Scalability:
Number of Points

All experiments:
faster as points are added

EXPERIMENTAL RESULTS

Scalability: Number of Trajectories

All experiments: faster as trajectories are added