Exploring Temporally Evolving Communities through the Lenses of Location Semantics

Olivera Novović[1], Sanja Brdar[1], Apostolos N. Papadopoulos[2]
[1]BioSense Institute, University of Novi Sad, Serbia
[2]Department of Informatics, Aristotle University of Thessaloniki, Greece

INTRODUCTION

Mobile phone service providers collect large volumes of data related to telecom traffic generated by users. Significant information is recorded in these datasets, and since the data is geo-referenced it has enormous potential for identification of human connectivity patterns in spatio-temporal context.

On mobile phone data set covering Milan city we **detected communities** from connectivity patterns and explored their **time evolving characteristics** through the lenses of location semantics. In this way we anticipated and explored dynamic change in communities on a city scale.

TELECOM AND LOCATION SEMANTIC DATA

1. CDRs provided by the Semantics and Knowledge Innovation Lab (SKIL) of Telecom Italia, time period: November and December 2013, covering spatial area of Milan city with surrounding area
2. Copernicus Land Monitoring Service – Urban Atlas – land use and land cover data
3. Open Street Map – points of interest

COMMUNITY DETECTION AND FREQUENT COMMUNITIES

We performed community detection using Louvain algorithm over graphs generated from telecom data. The results represent daily based snapshots of community structure over telecom network. Although community structure differs for each day, some similar patterns are repeating. We were interested to detect structures that are consistent over time, for that purpose we applied FP-Growth algorithm. Fig. 1 presents map of Milan city overlaid with frequent communities detected from telecom data around selected points of interest.

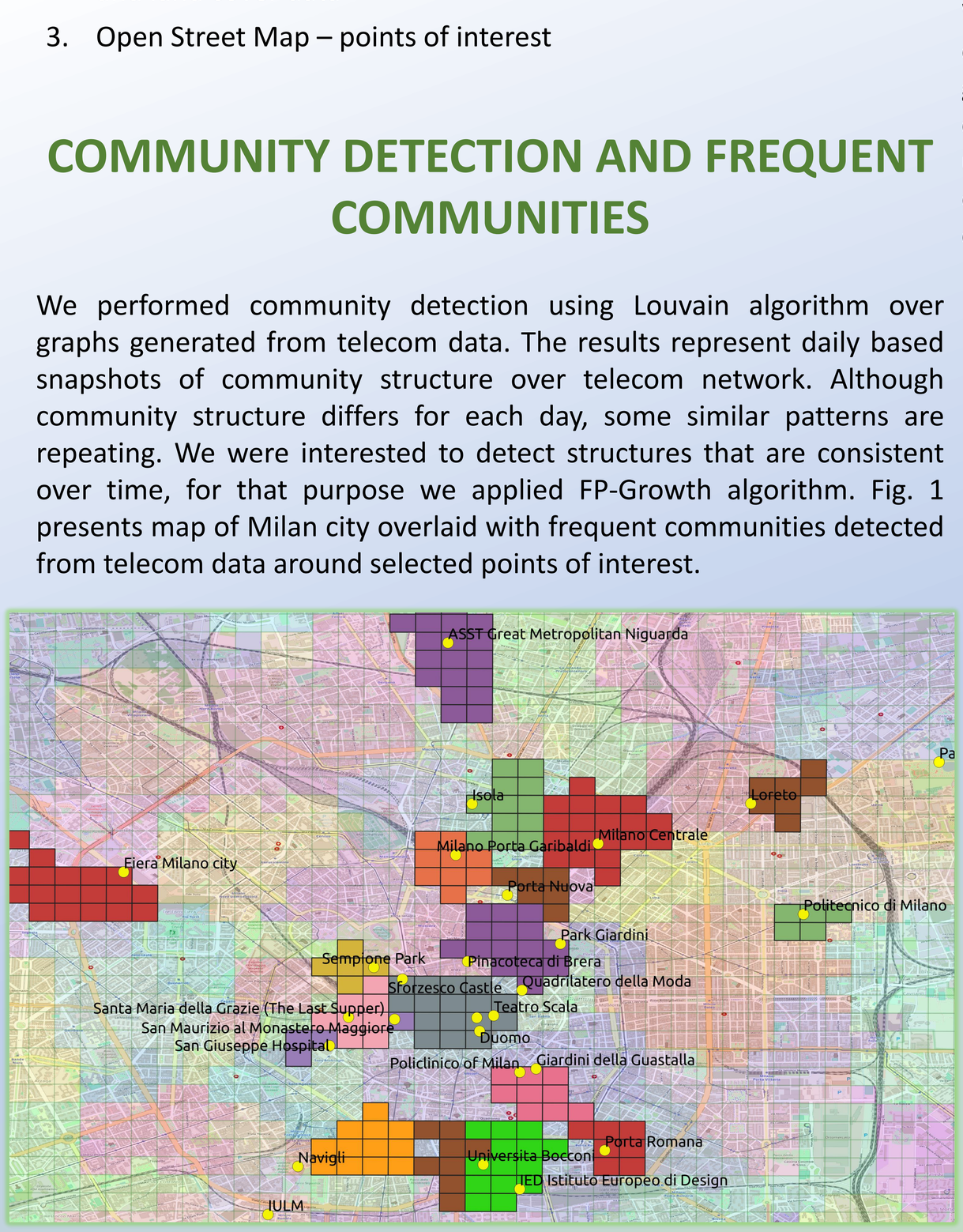

Figure 1. Frequent items generated clusters over selected locations in Milan city

TEMPORAL EVOLUTION OF COMMUNITIES

Community structure differs significantly from day to day. Community associated to specific location varies in shape, size and spatial distribution. We applied additional measures to evaluate temporal evolution of the communities, such as area of the communities and pairwise distance between location point and centroid of each community related to that location. In Fig. 2 we present the dynamic of change in community area for two locations with different semantics. The selected areas are Bocconi University and Duomo Cathedral in the city centre.

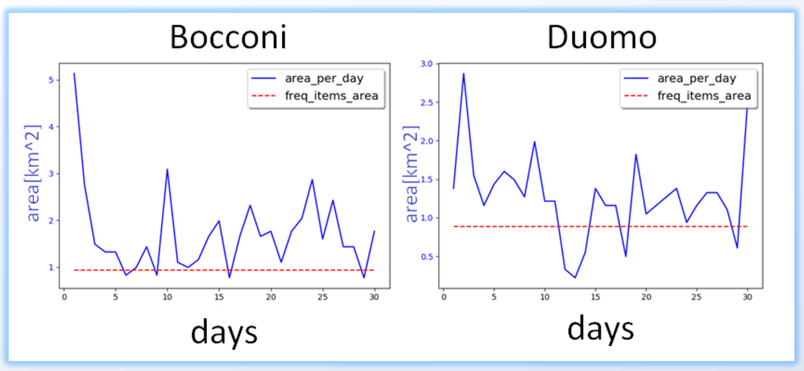

Figure 2. Area of communities generated daily base compared to area of frequent community

From Fig. 2 we can notice that Duomo has more stable community than Bocconi. Bocconi community significantly change in covered area compare to its frequent core.

When comparing pairwise distances between location point and centroids of selected communities, we can observe few picks in the graph which indicate that community is distributed across city containing disjoint parts. From Fig. 3 we can notice that Bocconi has unusual high pick at 10th day, while Duomo has it on 2nd and 9th day. In each case the reason behind such pattern is spatially distributed community.

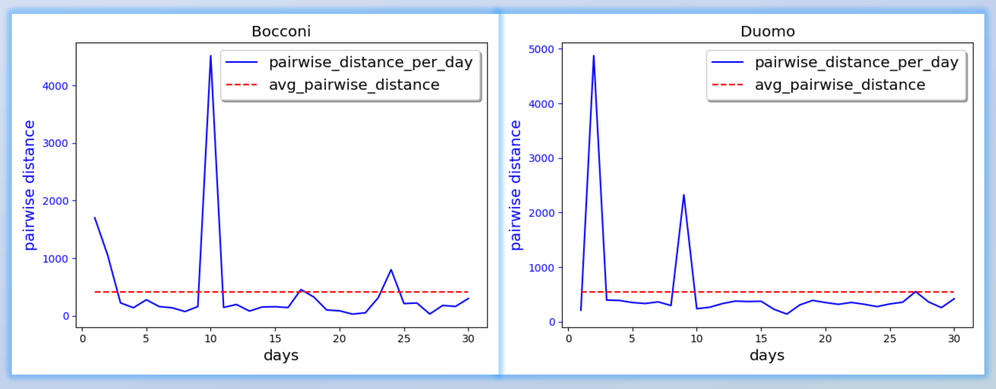

Figure 3. Pairwise distances between location point and centroids of communities

Spatial distribution of communities is also changing through time. Communities are moving from day to day, covering different areas of the city. When community between days is similar, centroid points are close to each other, but different pattern is occurring also.

From Fig. 4 we can observe how centroids of communities are spatially distributed in specific direction. Such behavior is observed for communities formed around Duomo Cathedral, while for other locations spatial direction of communities is different.

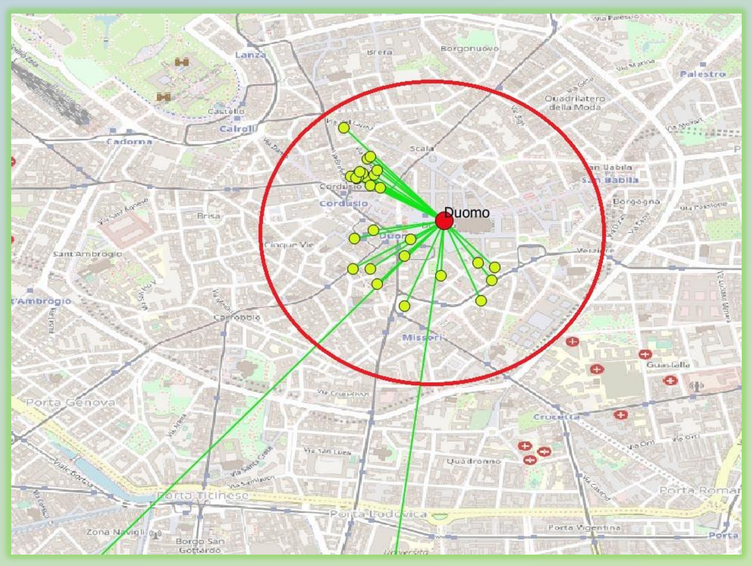

Figure 4. Spatial direction of communities related to Duomo