AI for Public Administrations: Research at UNIFI DISIT Lab

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Abstract

This paper summarizes the activities regarding the development of Artificial Intelligence (AI) for Public Administrations by DISIT lab of the University of Florence, UNIFI, node, during the last recent years in the context of a number of national and international projects.

Keywords

Artificial Intelligence, Explainable AI, Agent Based, Machine Learning, Deep Learning, Decision Support Systems, neuro-symbolic, Optimization, Genetic Algorithms, Natural Language Processing

1. Introduction

In the recent years, we have observed a strong increment of interest in AI solutions on Public Administrations as enabler for decongestion, reducing pollutant, increasing service accessibility, improving quality of services, efficiency and sustainability. Most of the activities is related to the implementation of the so-called smart services which in most cases have been leveraged by precise predictions, and a new generation of decision support systems, DSS, to perform what-if analysis and plan optimizations, where reinforced learning and neuro-symbolic solutions have been adopted. The DSS, are also activated during the operation by early warning solutions which technically are enabled by AI for anomaly detection, and by XAI, explainable AI. Behind the scenes of the visual interface, of the visual analysis, and business intelligence tools a large number of AI algorithms have been developed by DISIT lab of the University of Florence, and in most cases exploiting the Snap4City infrastructure of DISIT lab, also adopted by CN MOST, CN HPC, ISPRA JRC and many cities and areas in Europe, and worldwide.

2. Projects

In these recent years, DISIT lab has actively coordinated and/or participated in a number of projects and actions (the full list is reported on DISIT Lab (https://www.disit.org) or Snap4City portals (https://www.snap4city.org).

- **Operation and Plan, Transport Infrastructure and Facilities Support as a Service (OPTI-FaaS),** a Flagship of CN MOST (the national center on Sustainable mobility in Italy, Spokes 8 and 9, PNRR, NextGen EU), which aims to reduce congestion, increase access to transport facilities by using AI, exploiting an instance of Snap4City platform for AI solutions as a service. A second Flagship, called *LeverageOPTIFaaS* of CN MOST with additional activities on the same research line. https://www.snap4city.org/1008, https://www.snap4city.org/1096.

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- **Solutions for Safe, Sustainable and Accessible Urban Mobility (SASUAM), a Scalability project of CN MOST** to produce scalable methods and algorithms for urban traffic management. The contribution was on producing AI based generative optimization solutions for the decongestion, accessibility and safety of urban traffic, and new agent-based solutions to match demand vs offer. https://www.snap4city.org/999.
- **Collaborative explainable neuro-symbolic AI for Decision Support Assistant (CAI4DSA),** funded by the NextGen EU, "Future Artificial Intelligence – FAIR", PE1, Spoke 1. The outcomes of CAI4DSA are AI algorithms and tools to enhance decision-making processes, contribution to the theoretical understanding of how AI, neuro-symbolic AI, and XAI, can leverage DSS in multiple domains for public administrations. https://www.snap4city.org/1000.
- **Integrated interoperability support for citizen and public administration services (Sii-Mobility),** .founded by Italian ministry of research as national smart city. It aimed to develop interoperability and AI solutions for mobility and transport, including algorithms and infrastructures. https://www.snap4city.org/412.
- **Understanding traffic flows to improve air quality (TRAFAIR),** CEF project of EC. In this project, we developed scalable solutions for computing 3D pollution flows on the basis of the traffic flow in complex urban networks. https://www.snap4city.org/500.
- **Civil Protection for the City (PC4City) founded by Foundation CRF.**. A new AI solution for predicting landslide has been developed based on Deep Learning and XAI, rather than the classic susceptibility assessment methods. https://www.snap4city.org/803.
- **Sustainable Heritage Management towards Mass Tourism Impact thanks to a holistic use of Big and Open Data (HERIT-DATA),** Interreg MED of EC, which conquered the EC Flagship label for its merits. HERIT-DATA aimed to reduce the impact of tourism activities on cultural heritage (and over tourism) by AI and Big Data exploitation, by also computing reputation and people behaviour analyses, making predictions and causality analysis. https://www.snap4city.org/629.
- **Agile Justice** (Giustizia Agile) projects of PON, to promote changes in the organization of work and make justice more effective and closer to citizens. In the project, DISIT lab developed AI/XAI solutions based on NLP and BERT to predict the mediation propensity of the disputes. https://www.snap4city.org/1099.

3. Research Activities

In this section, the research activities related to AI for public administrations carried out by DISIT Lab of the University of Florence is reported and commented, mainly referring to the above listed projects.

3.1. AI for Urban Traffic Flow

In urban areas, the knowledge of the real time traffic flow status in each segment of a whole road network is a fundamental information to implement a large number of smart services to reduce congestion, such as: efficient routing, planning of public transportation, planning healthy walk, etc. Rescue teams, police department, and ambulances need to know with actual real time status of the traffic road network. One possibility to get real time traffic flow data is to acquire the information from mobile apps, navigators, on board units, etc., and merging multiple sources. Alternative and more precise solution could be to use traffic flow sensors. The flow sensors are scattered on the road network since it can only be placed in critical informative points and predictions can be also produced. Short and long terms predictions have been initially produced by classic ML approaches [1], and more recently by using deep learning, DL, as Convolutional-Bidirectional-LSTM models [2]. DL demonstrated to be much more effective than classic ML solutions. The measure of traffic and their prediction do not solve the needs of having a traffic flow status on the whole network segments, the so-called traffic flow reconstruction, TFR, is needed (Sii-Mobility). The knowledge of traffic flow in a number of points would not be enough to

reconstruct all flow. In alternative, solutions are needed to compute traffic distributions at junctions and from them to produce the TFR [3] by solving a partial differential equation, PDE, Navier Stokes, exploiting GPU infrastructure to provide results in quasi real time. It is also easier to compute the TFR when small parts of the road network are taken into account and to perform the so called What-if analysis [4]. More recently, the TFR has been also computed by using neuro-symbolic approaches that preliminary adopt a solution of the PDE which is regularized by a neural network process, thus proposing a hybrid solution [5] (CAI4DSA).

3.2. Optimizing Traffic Light Plans for fast services

The knowledge of traffic status over time can be exploited to optimize traffic light settings at junctions. The traditional approaches adopt fixed traffic light plans to synchronize several junctions and create the so-called green waves. Recently, solutions based on reinforced learning are feed with local status information of the vehicles waiting at the junctions to dynamically adapt the traffic light timing. On the other hand, this approach has a limited attention to synchronize the traffic lights with high speed/rate busses and tramways, which should not be stopped at the junctions without consequences to the degradation of service. To this end, we developed a set of solutions based on Genetic Algorithm [6] to compute the optimal traffic light plans of a set of junctions which are exploited by a number of tramway lines (CN MOST). More recently a new solution has been identified by using reinforced learning plus a number of domain specific formulas (neuro symbolic approach) [39].

3.3. Effects of Traffic on Urban Services

In the mobility and transport domain, services for parking, sharing, etc., have to be efficiently managed. The smart parking solutions exploit reliable predictions of the number of parking lots as provided to drivers in time, may be 15/30/45 minutes in advance, when they plan the last travel segment to destination. The knowledge of the location of a free parking reduces the time spent in searching for a parking, since it has been estimated that in downtowns event the 30% of moving cars are looking for parking. Parking lots can be on-roads and off-roads, and AI models for computing predictions have produced by using traditional models in [7] (Sii-Mobility), and later by using DL producing much better results. In most cases, the features relevance analysis has stressed importance of traffic and weather conditions in the predictions [8]. Similar results have been obtained in predicting the number of bikes for short- and long-term predictions [9, 20, 11] (CN MOST).

3.4. Matching Mobility Demand with Transportation Offer

A relevant problem in the context of mobility and transport is the match from the transportation offer and the mobility demand. The offer is typically presented by the actual schedule of all the transport services (busses, trains, taxi, sharing, metro, tramways, etc.), and the demand is the actual needs of people in moving from some origin to a destination in a graph. The match, in terms of local and global KPIs, has a huge value for public administrations and mobility operators that are interested to improve the transport services. Most of the simulators are complex and time-consuming agent-based solutions, which are (i) proprietary and very expensive, or (ii) open sources and both may be limited in modelling the most recent offers of services. In this context, with the aim of developing a more flexible, reliable and faster solution a new agent-based solution has been developed outperforming SUMO open-source simulator in matching [12] (CN MOST). The results have been obtained by modelling agents in a more flexible manner to reduce the computational complexity.

3.5. Effects of Traffic on Emissions

One of the effects of transport systems are the emissions since most of the travel means are powered by fossil combustible, so far. The amount of CO2 and NO2 emissions in a city mainly depend on the distribution of vehicle kind population, as their age, number of Km performed, and also by the actual

traffic behaviour. In particular, the emissions are higher in the cases of stop and go and less in fluid traffic conditions. The estimation of the correct parameters depend on the city and the calibration of the estimation model is not a trivial process [13]. Once estimated the emission factors, the amount of CO2 emitted per car, per Km in the different conditions the global and local estimation of CO2 emissions can be computed. The emissions are a critical issue for municipality which may be taxed by the Europe on the basis of specific long and short term KPI. For example, on the basis of the overage value of NO2 estimation in the whole year, making the long-term prediction of this metric a very relevant tools to avoid taxation [14] (TRAFAIR).

3.6. Monitoring and predicting Environmental phenomena

The emissions and pollutants are one of the hot topics of the modern cities. In most of the above depicted AI solutions, the data have been collected as time series coming from sensors. These data, as well as derived insights, can be affected by anomalies that should be identified as soon as possible for early warning the maintenance teams and in critical cases, civil protection, fire brigade, etc. [15]. XAI, techniques can be used to analyse time series, features effects, and to create predictors and early warning solutions [16]. Also, satellite data can be used for monitoring despite their complex management and exploitation [17]. Satellite data have been profitably used, together with a large set of other open data, for predicting 24 hours in advance landslides using DL and XAI (PC4CITY) [18].

3.7. AI for Urban Tourism Management

Many cities in Europe are targeted by huge flows of tourists. Recently, HERIT-DATA flagship project provided AI solutions addressing the phenomena of over-tourism with pilots in whole Europe. AI is helping on monitoring and predicting people flows [19], in the computation and prediction of reputations [20], in the classification of the user behaviour in the city [21], and finally in providing help desk assistants [22]. In most cases, the results are produced by processing social media and messages by NLP and sentiment analysis. These activities are particularly sensitive to the privacy and thus they have to be compliant with GDPR. To this end, a relevant stream of AI solutions for people counting and tracking solutions based on thermal cameras as the main sensors [23-26].

3.8. AI Supporting Legal Mediation

One of the actions of the Florence Città Metro in its first strategic plan has been to improve the capability of the legal system to reduce the processing time of legal disputes. This action was extended at national level with Giustizia Agile project, in which we developed an AI/XAI solution based on BERT to predict the mediation propensity of the disputes [27].

3.9. AI Development Infrastructures vs Digital Twin

In all the above research actions, the needs of collecting data, managing data (private, public, proprietary and sensitive according to GDPR and with a high security levels), supporting the possibility of developing AI solutions in a multi organization, multiuser environment has been very precious [28-29]. All the above solutions have been developed thanks to Snap4City infrastructure (https://www.snap4city.org), which provides support to CN MOST flagships and CN HPC pilots, on which data ingestion tools, data modelling, MLOps, and semantic knowledge representations and reasoning [30-31], IoT tools and visual analytic tools have been developed and exploited [32-35]. The capability of semantically knowledge modelling and reasoning, integrated with the related behaviour via simulation, enable the what-if analysis and optimisation, and recently is regarded as complete Digital Twins, which at local and global urban scales are the environments. They have to be supported by solutions in which AI models have been developed and put in execution [36-38].

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Declaration on Generative AI

The authors have not employed any Generative AI tools.

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