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How to Coordinate Decisions at Large Scale? A Hands-on Tutorial on Collective Learning for Smart Cities and Beyond

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***Abstract*—This 1.5-hour tutorial will provide an introduction to the theory and practice of multi-agent collective learning for coordinating distributed decisions at large scale. You will develop the required skills to work with the EPOS software artifact to solve distributed optimization problems in Smart Cities. The tutorial will also promote collaborations within the ACSOS community. PhD students and more senior colleagues are particularly encouraged to participate. No programming experience is required. You are also encouraged to bring in your own multi-agent optimization problem to explore a potential solution using collective learning.**

***Index Terms*—collective learning, multi-agent system, combinatorial optimization, coordination, decision-making, Smart City**

I. What this tutorial is about

This hands-on tutorial will provide an introduction to collective learning [1], [2] and the EPOS software artifact [3], [4]], a decentralized socio-technical approach for coordinating decisions in large-scale multi-agent systems. The tutorial will be highly practical with several application scenarios of Smart Cities, for instance: energy management, coordinated traffic control of autonomous/shared vehicles, load-balancing of bike-sharing stations, charging control of electric vehicles and other.

II. Tutorial goals

This tutorial has the following goals:

1) The development of hands-on experience in applying collective learning to Smart City applications
2) Developing skills in using the I-EPOS software artifact to solve a large spectrum of resource scheduling, allocation and management problems
3) Encourage and foster creative collaborations and synergies in the ACSOS community.

III. Learning activities

To meet these goals, the tutorial will run for 1.5 hours in two parts: theory and practice. We encourage participants to bring in their own multi-agent optimization problem to explore a potential solution using collective learning during the tutorial.

In the theory part, you will learn the following:

- Why coordinated decision-making emerges as one of the ultimate challenges to tackle tragedies of Smart City common problems
- How to model a large-spectrum of coordinated resource management scenarios in Smart Cities as discrete choice multi-objective combinatorial optimization problems
- How local planning of operational flexibility is applied to several Smart City application scenarios to empower a universal decentralized optimization approach.
- How to efficiently solve socio-technical optimization problems in a fully decentralized fashion using the collective learning approach of EPOS.

In the practice part, you will learn the following:

- How install and setup the I-EPOS software artifact [3]
- How to run decentralized socio-technical optimization without writing a single line of code.
- How to encode the input data (agents' plans) for your application
- How to work with the configurations parameters of the optimization
- How to evaluate and analyze the I-EPOS output data
- Advanced topics: Extending cost functions, loggers, real-world deployment and other.

IV. Prerequisites and intended audience

Several open datasets and templates will be provided for experimentation and testing [5]. No programming experience is required to follow the tutorial. The tutorial is relevant for the broader community of ACSOS, covering both theory and practice of autonomic systems, self-adaptive systems, multi-agent systems, distributed human-centered AI and learning, socio-technical systems in Smart Cities and Internet of Things. We particularly encourage PhD students as well as more senior colleagues to participate and explore synergies and collaboration opportunities.

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