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COUSCOUS: SUSTAINABLE URBAN DEVELOPMENT EMERGING FROM CUTTING-EDGE CLIMATE, SOCIAL AND COMPUTER SCIENCES

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URBARIA
HELSINKI INSTITUTE OF URBAN AND REGIONAL STUDIES

Urbaria Summary 2023/2

Sustainable Urban Development Emerging from Cutting-edge Climate, Social and Computer Sciences

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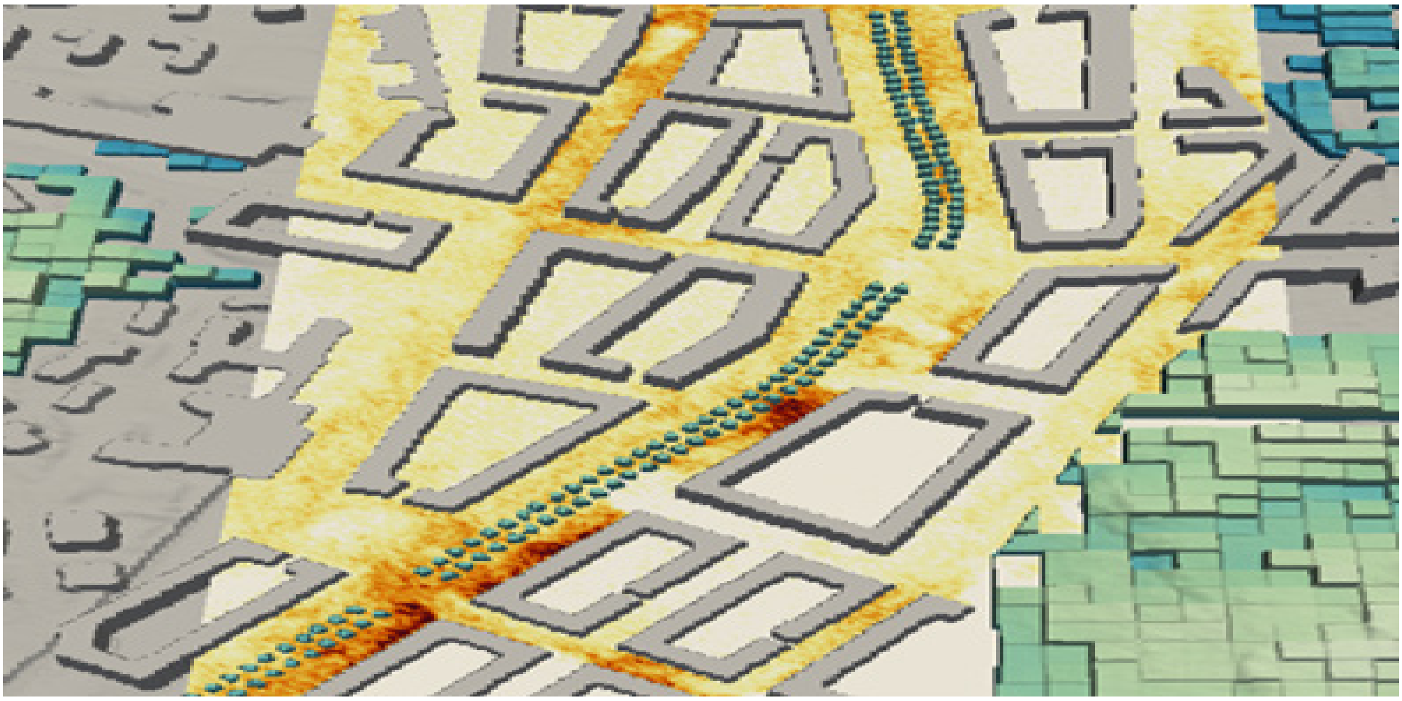

Picture: Land use draft 2021

- Urban planners utilize data analysis, stakeholder engagement, collaboration, and professional development to gather information and make informed decisions in urban planning.

- The CousCOUS project introduces an algorithm with data collection and optimization techniques to urban planning, leading to improved transportation efficiency and reduced environmental impact. This may result in better decision-making for urban planners and a higher quality of life for individuals in the cities.

Leveraging Urban Computing for Air Quality Management: A Smart City Approach

Urban computing, as a smart city service, is revolutionizing air quality management by combining sensor networks, data analytics, and modeling techniques. Simulation-based monitoring and analysis of air quality data enable policymakers and stakeholders to make informed decisions and implement targeted interventions (Kaginalkar et al, 2021). Urban computing empowers citizens by providing air quality information, allowing them to make informed choices and protect their health. Data-driven policy-making and resource allocation facilitated by urban computing may lead to more effective pollution control measures and optimized urban planning (Delgado et al, 2023). Integration of air quality management into smart city initiatives promotes sustainable urban development and healthier urban environments. Empirical analysis reveals that cities embracing smart technologies exhibit significant improvements in their urban environments, including reduced pollution levels and enhanced public services. City smartness correlates with reduced income disparity, as smart city initiatives bridge the digital divide and create economic opportunities for all segments of society (Dashkevych et al, 2023). Urban computing contributes to narrowing the gap between socioeconomic factor based income groups by promoting inclusive growth and enhancing access to essential services (Dashkevych et al, 2023). Smart technologies and data-driven decision-making can create more equitable urban environments and foster inclusive urban development. Embracing urban computing as a core component of smart city initiatives is crucial for creating livable and thriving cities for present and future generations and an artificial intelligence based solution can be the future (Son et al, 2023).

A solution for future sustainable cities

The CousCOUS project (https://www.helsinki.fi/en/projects/couscous) answers to possible challenges of air quality by helping cities plan climate-healthy urban areas, considering future traffic flows and population structures alike. CousCOUS combines the fields of artificial intelligence, atmospheric and social sciences to an unprecedented extent and therefore advances the state of scientific research in all disciplines involved. The project provides decision-makers and city planners globally with novel, relevant information and algorithm for creating future sustainable cities. The consortium utilizes and analyzes high-resolution data from various sources, including population, climate and traffic data, and works in co-operation with relevant stakeholders. The well-being and health of urban dwellers are impacted by high air pollutant concentrations.

Challenges: through the lens of Computer Science

• How can we predict future population using AI-modelling utilizing high-resolution data on population and geographic information system (GIS) data about built environment structures?

• How should the reward function in Reinforcement Learning be composed to reliably accommodate information of very different nature (traffic, population, air quality) to provide meaningful suggestions for city planning?

• How well Machine Learning models built, trained, and tested in one city can be scaled for other cities in Europe?

• By working together and in close co-operation with city planners, we ensure that our research will have real life impact, especially in light of planning a new city boulevard in Helsinki.

Role of Artificial Intelligence in CousCOUS

In recent years, reinforcement learning has gained significant attention for solving various complex decision-making problems. However, traditional reinforcement learning methods struggle to handle large-scale problems with multiple objectives. Hierarchical Reinforcement Learning (HRL) provides a promising solution by decomposing complex tasks into multiple levels, each focusing on specific sub-tasks (Pateria et al, 2022). We aim to here give an overall view of the potential of HRL in sustainable transportation systems and of CousCOUS's novel algorithm designed for making a sustainably livable environment by optimizing air quality along with the easy commutability. The decomposition is done by dividing the tasks into multiple levels of abstraction (Mohammed et al, 2022). Our algorithm employs a hierarchical structure with an agent, to enhance the efficiency and environmental sustainability of commuting processes. The lower level focuses on optimizing individual commutes, while the middle and higher levels assess air quality and create a livable environment.

In recent years, the field of artificial intelligence has witnessed significant advancements in solving complex decision-making problems. Among the emerging approaches, Hierarchical Reinforcement Learning (HRL) has garnered considerable attention for its ability to address the challenges posed by large-scale, multi-objective tasks. HRL decomposes complex problems into multiple levels of abstraction, enabling more efficient and effective decision-making. Transportation systems, especially in urban environments, face numerous challenges such as congestion, pollution, and inefficient resource allocation. These issues necessitate innovative solutions that promote sustainability, enhance commuting efficiency, and improve overall environmental conditions. In this context, HRL presents a promising avenue to optimize sustainable transportation systems and travelling speed of the vehicles by integrating multiple levels of decision-making.

Our algorithm leverages the hierarchical structure of HRL to maintain the efficiency of individual commutes while considering the environmental impact of transportation choices. The algorithm incorporates temporal abstractions with Artificial Intelligence (AI) based agent that considers:

a. The lower level focuses on optimizing individual commutes, allowing the human agent to make informed decisions regarding route selection, transportation modes, and travel times. These choices are recorded in a database for subsequent analysis.

b. The middle level introduces an optimizer that records the data collected from the lower level to assess and compare the current air quality with previous measurements. If the air quality is found to be suboptimal, the algorithm loops back to the lower level to optimize vehicle speeds, aiming to minimize emissions and improve air quality.

c. Finally, the higher level evaluates the overall livability of the environment by assessing the achieved air quality. It ensures that the air quality meets predefined thresholds to create a sustainable and healthy living environment for the community. By employing HRL in this context, our algorithm contributes to optimizing individual commutes, reducing emissions, and creating livable urban environments.

Through this research, we aim to pave the way for the development of more sustainable and efficient transportation systems that prioritize environmental considerations and enhance the quality of life for urban communities.

Summary

HRL offers a powerful framework for tackling complex decision-making problems, and our algorithm's application in sustainable transportation demonstrates its potential to revolutionize the way we design and optimize transportation systems. By considering both individual commuting efficiency and environmental impact, our algorithm is expected to contribute to creating a more sustainable and livable future. We begin by reviewing existing HRL algorithms that have been applied to various domains, such as robotics, game playing, and control systems. Notable algorithms include options frameworks, MAXQ, and FeUdal Networks.

We are proposing a novel algorithm i.e., 'HRL with contextual intelligence' and compare it with the benchmark algorithms. We expect that our algorithm outperforms while explicitly addressing the sustainability of transportation systems by integrating socioeconomic and environmental factors based decision-making process.

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