Autonomous Unmanned Ground Vehicles for Urban Logistics: Optimization of Last Mile Delivery Operations

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Abstract

In an era dominated by ongoing urbanization and rising e-commerce, the efficient delivery of goods within cities becomes a major challenge. As a new element of urban logistics, we discuss the potential of autonomous unmanned ground vehicles (AUGV) regarding the last mile delivery of shipments to customers. We propose an optimization model to minimize the delivery costs of urban shipments using AUGV. Simultaneously, best locations from a set of existing stations are selected for AUGV positioning and optimal route determination. With our developed Location Routing Problem, we provide decision support for parcel service providers, city authorities, and other relevant decision makers. Regarding the Green Information Systems domain, we tackle the lack of solution-oriented research addressing a more sustainable and locally emission free supply of goods within urban areas.

1. Introduction and motivation

The world’s urban population is growing rapidly, already accounting for a share of 54% [1]. Combined with the continuous growth of e-commerce, urbanization leads to increased transportation requirements in cities. This represents a challenging risk of pollution and increased traffic, influencing the health and living quality of city populations. Aspects of sustainable public transport are already tackled and implemented through subway or bus networks, as well as car- or bike-sharing. Resource-saving and sustainable business-to-consumers (B2C) transport of goods represents a growing business sector as several cities conduct pilot projects to increase sustainability.

The urban last mile delivery (LMD) is the most expensive part of the supply chain, as high personnel costs incur [2]. Consequently, transportation companies seek to improve this section of their business. City authorities are also interested in LMD because it represents a growing source of pollution. To keep cities clean and to reduce the urban road traffic, action is required. One possibility represents the delivery of goods with autonomous unmanned ground vehicles (AUGV), also referred to as delivery robots, which are subject to different restrictions compared to conventional delivery vehicles. In addition to a range limited by the battery capacity, the storage space is typically divided into compartments. This represents a considerable restriction for the use of delivery robots, which must be taken into account at route planning. The development as well as the operative use of delivery robots strongly depend on the digitalization of our society. With today’s information and communication technologies, it is possible to move such robots autonomously within public space [3]. With the increasing e-commerce, more customers want to receive the ordered products as quickly as possible. This demand is addressed by same-day or even instant delivery services, where delivery robots may be able to assist the last mile transports of small goods. Based on these characteristics, delivery robots do not appear capable of solving the discussed problems completely, but represent a useful supplementary option saving personnel expenses, road space, emissions, and noise.

Besides these trends, our society is becoming increasingly aware of environmental and economic sustainability [4]. This attention is also recognized in Information System (IS) research, as information is a prerequisite for making appropriate decisions on sustainability actions [5]. The emerged research domain of Green IS addresses the transformative role of IS in the context of a sustainable society and business strategies, while considering the role of people and their livability. The foci in this field vary by conceptualization, analyses, design, and impact of such systems [5]. Studies on Green IS by Malhotra et al. [6] and Gholami et al. [7] reveal that design and impact-oriented research is lacking. Since the IS domain is described as an interdisciplinary space [8], we combine elements of operations research, management science, transportation, and logistics within our approach to support locally emission free deliveries.