Connected Swarm Cycling: a new Concept for Urban Mobility

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Abstract
Social group cycling shows a positive impact on facilitating urban cycling as a sustainable means of mobility while increasing cycling safety in urban area[3]. We present *Connected Swarm Cycling*, a new urban mobility concept for creating a group of people cycling together for a while in a common direction or destination. Supporting the implicit interaction within or between swarms, smart garment will be utilized to realize use cases like swarm member identification, or signaling in case of merging or splitting of swarms. In this paper, we present the underlying technological basis as well as some planned further developments. Further, we outline our research topics in the field of user group modelling and algorithms for implicit urban scale interaction of groups, specifically in the context of connected swarm cycling.

Author Keywords
bicycling; sustainable mobility; swarm; implicit interaction.

CCS Concepts
•Human-centered computing $\rightarrow$ HCI theory, concepts and models;

Introduction
Recently urban cycling receives more and more attention as a pillar of sustainable urban mobility. Increasing the

number of citizens using bicycles for everyday mobility discloses huge potentials to reduce congestion, define holistic transport concepts, reduce commuting time, and to plan and create a sustainable mobility infrastructure.

However, urban cycling is still facing serious problems. Especially, the fact that most commuting cyclists cycle alone exposes them to different dangerous situations. As an example, for trucks or cars solo-cyclists are often not easily visible on the road. Consequently, the risk of being overlooked is comparably high, especially in crowded traffic situations. Expressed in numbers for the city of Berlin, 5 cyclists were killed in 2018, 6 in 2019, and already 10 in July 2020[1]. Additionally, cyclists in urban areas often suffer from problems such as bad infrastructure, or aggressive behaviour of motorised road users.

Addressing an improvement of the situation for urban bicyclists, we introduce connected swarm cycling, as a new form of urban mobility. Connected swarm cycling adopts the "safety in numbers" approach stating that motorists are less likely to collide with a person walking and bicycling if more people walk or bicycle [2]. Cycling in a group enables cyclists to gain better visibility on the road as they ride as one bigger visible unit. In Germany groups of cyclists with more than 15 participants are allowed to ride side by side in road traffic. Cycle paths that must be used by solo cyclists are of no significance for such groups[2]. We assume that connected swarm cycling will change the experience of solo bicycling into a more social experience because naturally people in the urban environment tend to congregate in social groups and often develop a sense of social solidarity.

[1] https://adfc-berlin.de/radverkehr/sicherheit/information-und-analyse/145-unfallorte.html

[2] https://de.wikipedia.org/wiki/Verbandregel

Current state of the art already experiments with automatically inducting cyclists into a collective of nearby riders , letting their bicycle lights begin to pulsate in unison if cyclists get close to each other [1]. According to the authors, this creates a visually unified presence and extending membership in a self-organizing community that is increasing safety cooperatively. We believe, as a next logical step connected swarm cycling could be created as a new mobility concept. Our idea is to establish a peer-to-peer connection between cyclists in order to dynamically form groups of cyclists for everyday routes from A to B in the city.

Technological Concept

The idea of connected swarm cycling is to utilize the current mobility context of a user to create a so-called "swarm", a group of people cycling together with a common direction or destination. The general concept is based on the outcomes of the EU projects STREETLIFE and BIG IoT – BIKELIFE [4]. The technological outputs of these projects were put together into the Open Source Mobility App which provides a routing service for bicyclist. The unique feature of the Open Source Mobility App is that the suggested routes also show overlapping parts with other cyclists. These overlaps are defined as trip intersections. By visualizing trip intersections in the user interface, bicyclists using the application are able to find potential swarm routes.

In our actual research project *SocialWear*, we will further extend this technological basis and explore user group behaviour models and implicit interaction concepts for connected swarm cycling. When the swarm cyclists come together, smart garment will be used to implicitly communicate the presence and proximity of groups. In order to facilitate the creation of dynamic mobility swarms, the garment of individual users will be able to memorize the current group membership and to exchange information with other smart garment in range directly or via smartphone. Implicit interaction will notify users in case of new swarm members approaching, change of direction, swarm merging and splitting, or swarm termination points.

Figure 1 illustrates the high level architecture of the swarm cycling system. The routing service with trip intersection computing is provided by the back-end utilizing the Open Source Routing Machine (OSRM)[3]. Creation, update and deletion of swarms will first be detected within the Wi-Fi Direct mesh network of the cyclists. After that the back-end database will be updated using a RESTful api. The user interface will consist of the smart garment and will be connected with a smartphone using Bluetooth. As long as new swarm members are too far away from the swarm, the Firebase cloud message service[4] will be used to broadcast notifications to individual users and to synchronize the trip intersection information.

Research topics

Our main research goal is to develop user group models and algorithms for implicit urban scale interaction of groups in the context of connected swarm cycling.

User group models

In order to learn the social group membership of swarm participants, knowledge about behavioral patterns is required. We will investigate parameters that can be used in order to define the user models (e.g., user preferences, average speed, maximum speed, acceleration, daily cycling distance, cycling location/district, etc.). Focusing on edge-based machine learning techniques, we will further explore what can be learned from floating data. We will develop edge-based techniques for data collection and model shar-

[3]http://project-osrm.org/

[4]https://firebase.google.com/docs/cloud-messaging

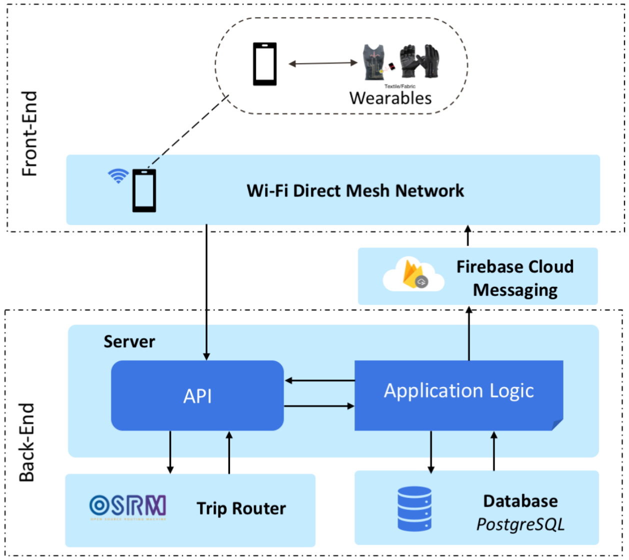

Figure 1: High level system architecture of *Bicycling Swarm*.

ing over a peer-to-peer connection. The calculation of user models will be implemented on device and possibly augmented with the shared data resulting in user models for user behaviour classification and clustering and the generation of group behaviour features. We further plan to explore recommendations for best matching (bicycling) groups. Finally, we will investigate possible transfer to other contexts (e.g., groups at big events, coordination of task forces, etc.)

Implicit interaction in the group context
Implicit interaction does not require explicit commands from a user. Instead, the activity of the user is interpreted as input in the specific context, whereas the system accordingly initiates appropriate actions. In the implicit interaction paradigm, it is essential to consider the unobtrusiveness of the context acquisition. In our work, we will use the situational contexts of the user such as the location (GPS coordinates) or the state of devices (e.g., Wi-Fi connection state) as implicit input into the system. Based on the situational contexts we will utilize geofencing[5] to generate system actions for different use cases, as e.g., if new users are approaching the swarm, joining the swarm, leaving the swarm, etc. The corresponding system actions will generate an explicit output in a multimodal manner. As an example, the members of a current swarm will receive a notification via the smart garment (e.g., the smart garment can be set into a pulsing mode), when a potential new swarm member is approaching the swarm. As the smart garment of the whole group will adapt to the context, the system action can be perceived peripheral (from the garment of other swarm members) with very low distraction. We assume that such peripheral signalling causes less distraction and more attention can stay at the actual traffic situation while the group can prepare for the newly joining member. We will investigate such effects in field trials. Different illumination forms and color patterns can be designed for signaling in different use cases.

[5]https://en.wikipedia.org/wiki/Geo-fence

Conclusion
We introduce connected swarm cycling, a social cycling concept supporting people cycling together with a common direction or destination. A major goal is to increase cycling safety in urban areas by adopting the “safety in numbers“ paradigm. We will investigate user group models and algorithms for implicit urban scale interaction of groups, specifically in the cycling context. Utilizing a Wi-Fi Direct mesh network, implicit interaction supported by smart garment will be investigated for specific use cases, like swarm creation, update and deletion, etc. As part of our future work, we plan to evolve a gamification concept for swarm cycling to incentivise swarm participation and positively effect the group behavior within and between swarms.

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