DOI: 10.32347/2412-9933.2021.47.57-62
УДК 004.9

Pasichnyk Volodymyr
DSc (Eng.), Professor, department of information systems and networks, *orcid.org/0000-0001-9434-563X*
Lviv Polytechnic National University, Lviv
Kunanets Nataliia
DSc (Eng.) in Social Communications, Professor, department of information systems and networks, *orcid.org/0000-0003-3007-2462*
Lviv Polytechnic National University, Lviv
Artemenko Olga
PhD, Associate Professor, Department of computer systems and technologies, *orcid.org/0000-0002-4057-1217*
PHEI "Bukovinian University", Chernivtsi
Fedorka Pavlo
Assistant, department of systems software, *orcid.org/0000-0002-9242-5588*
Uzhhorod National University, Uzhhorod
Nebesnyi Ruslan
Assistant, department of computer science, *orcid.org/0000-0001-8886-8346*
Ternopil National Technical University, Ternopil

USING MOBILE CROWD SENSING FOR SOCIAL DISTANCING REAL-TIME NAVIGATION

Abstract. *The study focuses on current trends in the use of smartphones and other smart devices to provide information support to users in a COVID pandemic. The perspective adaptations of mobile crowd sensing (MCS) information technologies to ensure the social distance of pedestrians while walking through the city are described. Specifics of navigation and data collection from users' smartphone's sensors in the case of open space and in large buildings (stations, hospitals, government agencies and other social infrastructure) navigation are considered. A project approach to the creation of a mobile recommender application for a safe walking route in real time with the support of social distancing based on hybrid tourist recommender systems, mobile crowd sensing and big data analysis is proposed. The main problems and challenges presented with the implementation of such a project are outlined. Safe navigation of users in large rooms is also an increase in the urgent task. After all, even the best strict guarantees of the ban do not make it possible to determine the assessment of health care facilities, construction of social, educational, trade, transport infrastructure, etc. The main problems and stages of data extraction from the user 's device are considered, as well as the approaches to the organization of user navigation within the city are analyzed: both indoors and outdoors. The algorithm was proposed for building a safe route recommendation with mobile crowd sensing application with multi-criteria context evaluation for social distancing real-time navigation.*

Ключові слова: social distancing navigation; e-tourism recommender systems; urban route planning; crowd prevention management; smart city

Introduction

Mobile crowd sensing (MCS) is a technology that involves a large number of people with different sensory and smart devices, which can collect, transmit multiple types of data and/or receive certain information about possible crowding [1]. Prior to pandemic, popular areas of application of human flow management technology were transport, tourism, event management, and more [2; 3]. Nowadays, the current directions have changed, as has the very definition of the crowd: three people in a narrow corridor or elevator is now also a dangerous crowd [4].

Emphasis in human flow management technologies has also changed. Crowd management as such has come to the fore, it is now important to prevent the formation of crowds and assess the risk of its formation [5].

Accordingly, the need for technology has changed. Mobile means of interactive navigation, in particular, are currently in demand. And the current level of progress of mobile devices allows them to upload in real-time all kinds of sensor-sensitive data to the data collector's server over various wireless access networks, such as cellular or Wi-Fi, at a convenient time and location [6].

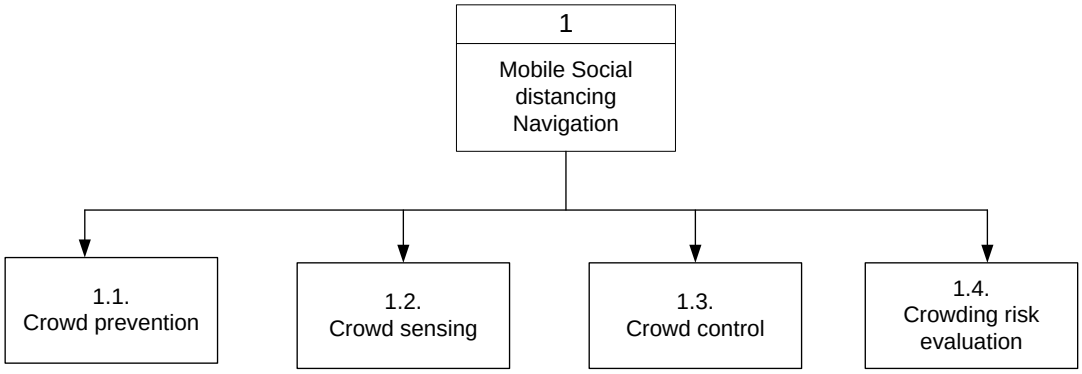

Figure 1 – Technologies for crowd management

In urban area access to Wi-Fi or other networks is no problem at all, so Mobile crowd sensing can be realized in real time way [7].

Human crowd prevention management: case study

Depending on the level of user involvement, MCS can be distributed in two categories: opportunistic communication and participatory communication. The first is a passive process where data is collected by the gadget automatically without the user's knowledge. The other is an active process when users need to directly initiate data collection and analysis actions [1; 8].

Mobile crowd sensing provides exceptional functions for gathering and processing big data arrays of personalized and group navigation data. Such as [1]:

1. Scalability;
2. Flexibility;
3. Self-Determination of User Behavior;
4. Different data quality;
5. Weak power limitation.

Preventing unexpected and unintentional crowds is one of important tasks for the health security of urban residents in the time of COVID pandemic [9]. The use of movement and other types of data, collected from smartphones and gadgets of city residents, as well as data from cellular stations can be used to optimize the walking route with the importance of social distancing provision [10]. The previously listed data sets belong to the category of big data [11]. Therefore, the projects for social distancing user support applications should be based on big data analysis, context analysis and smartphone data transmission functionality [12].

For MCS, there are several special forms and characteristics. Various are elaborated as follows:

– Cooperative sensing;
– Group sensing;
– Diversity of mobile users.

Cooperative sensing is an significant approach to benefit social distancing. Data collected from each user (for example, about it's location) is important for estimation of of human density [13]. So, when we talk about safe pedestrian route in time of pandemic, it is a good alternative for heterogeneous users to cooperate with each other to obtain a larger surplus.

For a task of crowd prevention management and smart pedestrian navigation group sensing data is much more valuable than single user individual profile data [14]. It enables so-called social recommendation.

The diversity of user's behaviour and frameworks is also significant factor to be considered for the projects of social distancing navigation applications. People own different types of gadgets, they create different access levels for data transmission, or even the ones, who forbid the access to everything they can – they all give pieces of the big puzzle for mobile crowd sensing software. Users with different environment and patterns (e.g., location, age, gender, activity habits, etc.) transmit more valuable information than users with similar profiles. The problem is to interpret adequately all this items of data [15].

Research Challenges

The main research challenges of the project are related to problems of data collection from different types of gadgets, which provoke data quality questions. Also it is important to eliminate data redundancy and to consider the requirements for confidentiality and security of personal data when using mobile applications. To create a good and safe route the recommender system needs lo learn the spatial, temporal and spatio-temporal behavior of pedestrians on the specific area. So the training sample data array is needed, to and, , etc. The main ones were grouped as follows:

– Development of a simple and valid data collection mechanism for the training sample.
– Ensuring the same quality of gathered data array and elimination of data redundancy.
– Optimizing activities for users while passing their route.
– Optimizing behavior of the users on spatial, temporal and spatio-temporal levels [16].
– Privacy and Security.

As a result, for a system approach it is also an important issue to find the way to learn and optimize the behavior (on every level) of it's users. The single user trajectory and activity matters and the multitude of user collective behavior are important. Due to the danger of unintentional crowding when occasionally many people just appear in the same time (or in short timeline) in the same place (Fig. 2).

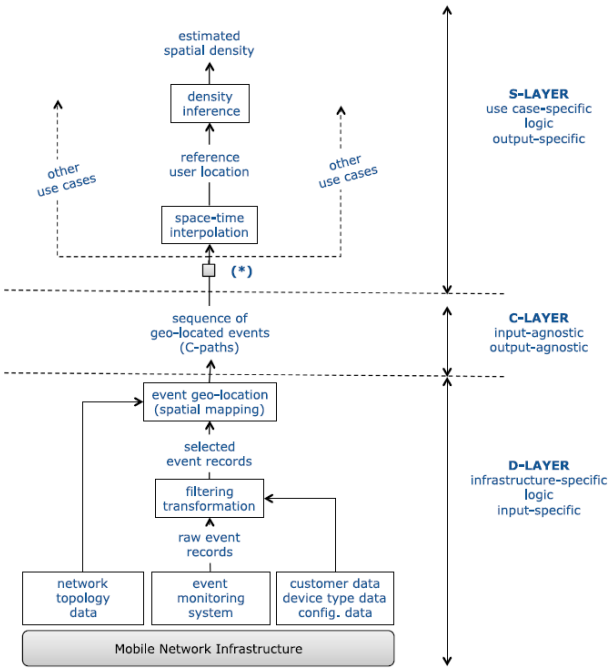

Figure 2 – Estimation procedure of the human density (crowd level) used mobile location-based social distancing recommender system [13]

Mobile Social Recommendation

In the city, as urbanized objects, people view social interactions with each other. The progress of mobile information technologies and the Internet of Things has led to a passive form of socialization. Experiences, feedback and evaluations of other people are guided by the recommendations that the user receives in these or other recommendation systems. The user himself is clearly not interested in this, for example, the rating route. The system is designed to remove the best rated alternatives. Or another textbook, when travel users are offered the route (the most popular one) that has more GPS tracks from other users.

If we talk about MCS, then in this area there are two main trends in the inclusion of feedback from society: friendly recommendation and social activity recommendation [8].

Friendly recommendation stands on the fact that the similarity of user profiles is assessed and then the positive experience of similar profiles is preferable to build a recommendation [17 – 19]. Social activity recommendation applications provide alternatives based on group activity (give the most popular item among all users).

However, the analysis of data from profiles and responses of many users has a number of disadvantages. In particular, related to the quality and reliability of data. And also with the users refuse to provide data. The latest (mid-2021) updates to mobile operating systems and user software are just to notify the user and allow him to deny access to smartphone devices and data for collection. While collecting smartphone's sensing data, the application must get as large array of data as possible [18]. Nevertheless, independently to the amount of the collected content or context data, the quality and actuality of each item of collected with the use of gadget data is important. In multiple situations smartphone users not only forbid the access to the sensors and forbid data collection, but also submit (intentionally or unintentionally) some invalid or unreliable data. So the exactness of data analysis result will be elaborated by this low-quality data. For that reason, the quality of received sensing data, is one of the most essential factors in the mobile recommender systems work. Especially for those who have to work in real-time mode [17 – 20]. For the crowd sensing ones this problem is also important.

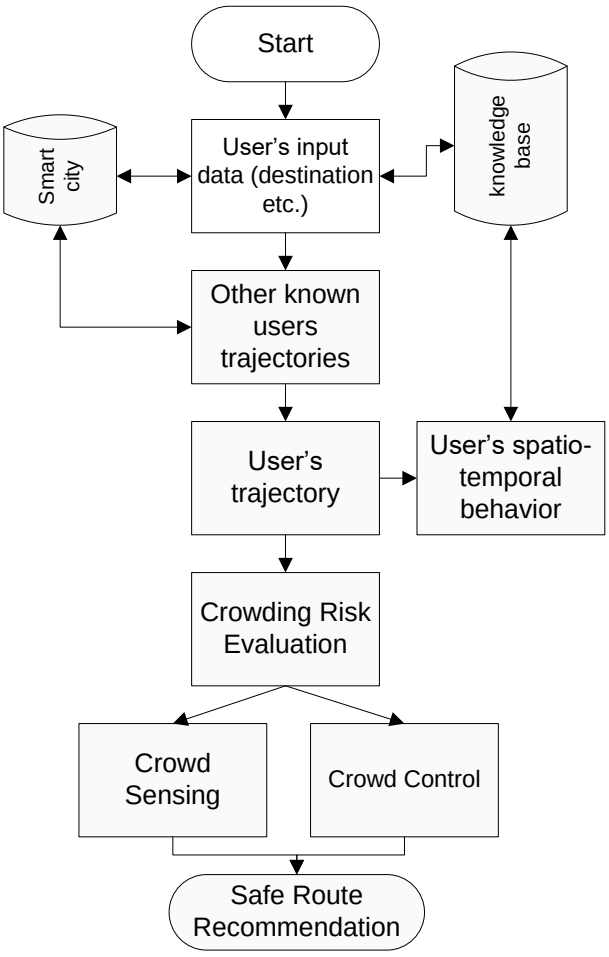

Figure 3 – The process of safe route recommendation with mobile crowd sensing application with multi-criteria context evaluation for social distancing real-time navigation

The approach to solve the problem of false or incorrect data may be in estimating some sort of

"reputation of the device" – for example, by data quality evaluation (for big data provided by a smartphone). If the specific gadget gives controversial or incomplete data it can be estimated with lower rating or, maybe, excluded from data array. It reflects the truthfulness of newly received data. Therefore, the overall quality of the collected data can be improved, as well as the accuracy of social recommendation can be elaborated and made better, considering the reputation of smartphones, used in the system.

Mobile indoor crowd sensing technology

Safe navigation of users in large rooms is also an increase in the urgent task. After all, even the best strict guarantees of the ban do not make it possible to determine the assessment of health care facilities, construction of social, educational, trade, transport infrastructure, etc. In such institutions, the necessary premises are large and spacious, which, on the one hand, allow social removal and demarcation of human flows. In addition, their size is such that a large number of assessors, which increases the risk of aggregation and transmission of viruses, respectively. Also, in large rooms there are so-called "bottlenecks" – areas where people gather in any case or a large number of people, alternately in the center is in them at very short intervals. Such areas include checkpoints, elevators, recreation areas and toilets.

In the conditions of easing of quarantine restrictions and return to normal functioning of society the need for the organization of social distancing as a preventive measure does not decrease. Therefore, the technology of intelligent navigation of flows of people in large rooms is becoming even more relevant.

The organization of management of human flows indoors has a number of tasks and problems of their implementation [21]. Smartphones and mobile technologies help alleviate these problems.

First of all it is necessary to organize localization of users indoors. This task is more complex than locating an object in open space. For example, popular GPS tracking technology cannot be used indoors. As a solution to the problem of a local nature (tracking the location of staff or a certain category of visitors) can be used special transmitting devices. However, it is not possible to equip all visitors with such devices. Therefore, to determine the location of a person indoors, you can use only signals from the user's smart devices. Therefore, it is necessary to find such a mechanism based on the functionality of gadgets and wireless technologies to determine as accurately as possible not only the location of a person, but also his trajectory. There is another problem: signal distortion and localization errors indoors.

The next task in the organization of safe navigation of human flows in the room is the exact and complete definition of "bottlenecks", where most often or most likely a crowd is formed. Yes, some of these critical points are obvious, such as entrances and elevators. However, when analyzing the spatio-temporal behavior of people indoors, you can identify additional areas of crowd accumulation. In particular, those where the crowd occurs only at certain time peaks or under certain circumstances. Mobile crowd sensing can be used to solve this problem.

Indoors mobile crowd sensing differs on signal typed used, sensing devices, integration techniques etc. Signals are the main problem for indoors localization and navigation. The are four types of signals, the gadgets may give, suitable for indoors navigation: radio frequency signals, ambient signals, motion signals, and visual signals. The trick is to analyze one of them (or combination) with spatio-temporal behaviour of the user and time-spatial characteristics of other users' signals.

It is difficult to receive good indoors localisation precision using only one type of signal. In addition, people with different types of gadgets leave different signal traces. So integration technology for combining and comparison of different signals is also necessary.

For creating competent mobile crowd sensing recommender system [17] with multi-criteria context evaluation for social distancing real-time route planning and safe navigation in urban area it is necessary to provide user support both outdoors and indoors. So, creating efficient indoors crowd management technology is important step.

Conclusions

The research highlights the specifics and stages for the design and development of mobile recommender systems for intelligent navigation of pedestrians in areas of high urbanization in conditions of quarantine restrictions and social distancing. One of the supplementary tools for projects of mobile recommender systems for planning safe routes, as well as support for social distancing in real time can be mobile crowd sensing technology. Combining its algorithms with the functionality of smartphones and other personalized gadgets can provide a technological basis for creating mobile recommender systems that will help city residents to adhere to social distancing and avoid crowds.

The main problems and stages of data extraction from the user's device are considered, as well as the approaches to the organization of user navigation within the city are analyzed: both indoors and outdoors. The algorithm was proposed for building a safe route recommendation with mobile crowd sensing application with multi-criteria context evaluation for social distancing real-time navigation.

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Received 24.05.2021

Пасічник Володимир Володимирович
Доктор технічних наук, професор, професор кафедри «Інформаційні системи та мережі», *orcid.org/0000-0001-9434-563X*
Національний університет «Львівська політехніка», Львів
Кунанець Наталія Едуардівна
Доктор наук з соціальних комунікацій, професор, професор кафедри «Інформаційні системи та мережі», *orcid.org/0000-0003-3007-2462*
Національний університет «Львівська політехніка», Львів
Артеменко Ольга Іванівна
Кандидат технічних наук, доцент, завідувач кафедри комп'ютерних систем і технологій, *orcid.org/0000-0002-4057-1217*
Приватний вищий навчальний заклад Буковинський університет, Чернівці
Федорка Павло Павлович
Асистент кафедри програмного забезпечення систем, *orcid.org/0000-0002-9242-5588*
Ужгородський національний університет, Ужгород
Небесний Руслан Михайлович
Асистент кафедри комп'ютерних наук, *orcid.org/0000-0001-8886-8346*
Тернопільський національний технічний університет ім. І. Пулюя, Тернопіль

ВИКОРИСТАННЯ ТЕХНОЛОГІЇ МОБІЛЬНОГО ЗОНДУВАННЯ НАТОВПУ ДЛЯ НАВІГАЦІЇ З ПІДТРИМКОЮ СОЦІАЛЬНОГО ДИСТАНЦІЮВАННЯ В РЕЖИМІ РЕАЛЬНОГО ЧАСУ

Анотація. *Дослідження зосереджується на сучасних тенденціях використання смартфонів та інших розумних пристроїв для надання інформаційної підтримки користувачам в умовах пандемії COVID. Описано перспективні адаптації інформаційних технологій мобільного зондування натовпу (*mobile crowd sensing *– MCS) для забезпечення соціальної дистанції пішоходів під час прогулянки містом. Розглянуто особливості навігації та збирання даних з датчиків смартфонів користувачів у разі навігації в рамках відкритого простору та у великих будівлях (транспортних станціях, лікарнях, державних установах та іншій соціальній інфраструктурі). Запропоновано проєктний підхід до створення мобільного додатка − рекомендатора для прокладання та супроводу безпечного пішохідного маршруту в режимі реального часу за підтримки соціального дистанціювання на основі гібридних туристичних рекомендаційних систем, мобільного зондування натовпу та аналізу великих даних. Окреслено основні проблеми та виклики, які виникають при реалізації такого проєкту. Безпечна навігація користувачів у великих приміщеннях − це також актуальна задача. Адже навіть найбільш суворі карантинні заборони не дають можливості виключити скупчення людей під час відвідування закладів охорони здоров'я, соціальної, освітньої, торгової, транспортної інфраструктури тощо. Розглянуто основні проблеми та етапи вилучення даних з пристрою користувача, а також проаналізовано підходи до організації навігації користувача в межах міста (як у приміщенні, так і на відкритому повітрі). Запропоновано алгоритм побудови рекомендації щодо безпечного маршруту з мобільним додатком зондування натовпу з багатокритеріальною оцінкою контексту для навігації в режимі реального часу із соціальним дистанціюванням.*

Ключові слова: навігація соціального дистанціювання; туристичні рекомендаційні системи; планування міського маршруту; управління запобіганням натовпу; розумне місто

Link to the article

APA Pasichnyk, Volodymyr, Kunanets, Nataliia, Artemenko, Olga, Fedorka, Pavlo, & Nebesnyi, Ruslan. (2021). Using mobile crowd sensing for social distancing real-time navigation. *Management of Development of Complex Systems*, 47, 57–62, dx.doi.org\10.32347/2412-9933.2021.47.57-62.

ДСТУ Пасічник В. В., Кунанець Н. Е., Артеменко О. І., Федорка П. П., Небесний Р. М. Використання технології мобільного зондування натовпу для навігації з підтримкою соціального дистанціювання в режимі реального часу. *Управління розвитком складних систем.* Київ, 2021. № 47. С. 57 – 62, dx.doi.org\10.32347/2412-9933.2021.47.57-62.