Considering the Need for New Aspects in Route Planners

Diogo Abrantes[1], Marta Campos Ferreira[1,2], Paulo Costa[1], Soraia Felício[2], Joana Hora[2], Camila D'angelo[2], Jorge Silva[3], Teresa Galvão[2], Miguel Coimbra[4]

[1] Faculdade de Ciências da Universidade do Porto, Portugal

[2] Faculdade de Engenharia da Universidade do Porto, Portugal

[3] Bosch Security Systems, Aveiro, Portugal

[4] INESC TEC - Institute for Systems and Computer Engineering, Technology and Science, Porto, Portugal

ABSTRACT

The rising number of people living in city centers is connected to an increase of private vehicles, traffic, and associated harmful effects. Efforts have been made to promote a modal shift to the use of more sustainable transportation means, such as walking and cycling, but several factors hinged to safety, comfort, and accessibility, still hinder this goal. Current route planners often focus on two particular dimensions, time and distance, which might not be enough to support other personal perceptions. We need to consider new aspects and different dimensions, such as air quality, noise levels, or people density, fueled by the recent advances in the area of sensorization and the Internet of Things. We tested the idea of an innovative route planner with surveys and focus groups and concluded that there is an interest for more power to customize personal routes, which could be a key element boosting soft mode mobility.

Keywords: Route planners, User research, Smart cities, Sustainable mobility

INTRODUCTION

BACKGROUND

Currently, more than 56% of the world's population lives in cities, and that number is expected to rise to 68% by 2050, meaning that around 2.5 billion people could be added to urban areas by then (Kiestra, Kondo and Clague, 2019; United Nations, 2021). Considering the attached environmental and social challenges, we can sustain that Smart Cities are becoming a need for modern society, as they bring advantages to citizen's quality of life, such as more free time, security, energy efficiency, and pollution reduction (Ortega-Fernández, Martín-Rojas and García-Morales, 2020; Su, Li and Fu, 2011).

That increase in population translates into more people on the move, and private vehicles became the main means of transport to satisfy the movement needs of citizens (Baena-Toquero *et al.*, 2014). The resulting traffic increase in city centers, along with associated harmful effects, have been countered with efforts to promote a mod-al shift to the use of more sustainable transportation means, such as walking and cycling (Dell'Asin, Monzón and Lopez-Lambas, 2015; Nieuwenhuijsen *et al.*, 2019). Moreover, the number of studies that measured a reduction of air pollutants from vehicles in city centers due to the pandemic lockdown, should be another advocate for less traffic on the road (Ropkins and Tate, 2021).

Agencies determine an overall air pollution category and issue recommendations for the general public and city policy makers, which are of paramount importance due to the evidence linking increased air pollution to the occurrence of respiratory and cardiovascular diseases, such as lung cancer, asthma, and ischemic heart disease (Franklin, Brook and Pope III, 2015; Eguiluz-Gracia *et al.*, 2020). Not only that, but urban noise is also a serious and underestimated environmental issue, being a key factor affecting the quality of life in modern societies due to its influence on a wide range of human activities (Tsalera, Papadakis and Samarakou, 2020). Continuous exposure to urban noise is considered one of the main threats to people's health due to the increased stress caused to humans and animals.

Fortunately, personal health and well-being concerns are increasingly present in populations, particularly in urban areas. The aging of the population, the growing adherence to the practice of physical exercise in public spaces, the perception of the need to adapt the architectural characteristics of cities to citizens with reduced mobility, the demand for healthy food, the use of sensors that monitor health parameters (Reames and Bravo, 2019), end up helping the promotion of more sustainable transportation means.

On the other hand, there are several deterrents, as many factors can affect the level of safety. The amount of road accidents and fatalities that take place in urban areas with pedestrians and cyclists (European Commission, 2007), weather conditions, lighting levels (Peña-García, Hurtado and Aguilar-Luzón, 2015), a poor or lack of maintenance of infrastructures (Winters *et al.*, 2011). All of these end up influencing

the citizen's safety and security perceptions (Park and Garcia, 2020), negatively affecting their choice of soft transportation modes (Silva and Silva, 2020). Soft mode users claim they feel they attract more attention from criminals (Silva and Silva, 2020), with fewer women declaring to feel safe comparing to men, while trying to be more aware of the presence of security monitoring, such as agents or cameras (Chowdhury, 2019). Other factors influencing the user's decision making are also related to travel time, economic aspects, parking, topography, and neighborhood/environment aspects (Shach-Pinsly, 2019).

MOTIVATION

Smart cities include sensor networks and connections of intelligent devices, and rising challenges are usually addressed by introducing new technologies, especially those associated with the Internet of Things (IoT). Sensors gather specific data regarding public transport information, traffic status, weather conditions, lighting levels, air and noise pollution status, energy consumption, among others, while other intelligent de-vices can feed surveillance and supervision systems. This IoT substructure can simplify operations and affect different features of a citizen's life by creating cost-effective municipal services, enhancing public transportation, reducing traffic congestion, ultimately keeping them safer and healthier (Talari *et al.*, 2017).

We find it necessary to provide that meaningful information to users in order to support their perceptions of personal safety and comfort while moving within urban spaces. Our approach is to lean on the potential of IoT and combine it with an innovative urban route planner that could provide the user with more power to tailor a route, using additional parameters towards their preferences, namely within the categories of safety and security, accessibility, as well as comfort and well-being.

Current route planners are vastly used in helping users find the best path between two points, while taking into account their mobility preferences. Although several options are available on the market, they often focus on two particular dimensions, time and distance, which might not be enough to support other personal perceptions. We need to consider new aspects and different dimensions, such as air quality, noise levels, accessibility levels, or people density. The recent advances in the area of sensorization and the Internet of Things (IoT) (Santos *et al.*, 2018) will hopefully allow us to envision a new tool with the goal to motivate the users' shift to more sustainable means of transportation.

METHODOLOGY

MAIN APPROACH

The chosen methodology consisted of gathering data to explore a few conceptions and perceive the viability of our proposal. It follows a user-centered approach in or-

der to validate ideas and understand user requirements and preferences, employing a variety of methods: i) a streamlined comparative analysis of currently available apps, in order to gauge their strengths and weaknesses; ii) an online survey to the general audience, in order to gather socio-demographic information, common impressions, preferences and habits; iii) focus group sessions, in order to collect information about individual perceptions of safety and comfort when moving, taking into ac-count personal characteristics and specific circumstances of travel.

COMPARATIVE ANALYSIS

A broad spectrum of apps that could relate in some way to the features we are proposing was collected, including route planners, air quality apps, sound monitoring apps, accessibility apps, city safety and security apps. Analyzing the route planners first gave us a general overview of what the bulk of the app should feature and how it compares to the others in the market.

However, since there are no known competitor applications combining all the features or sub-features we are proposing, the best way to perform the rest of the analysis was to consider the other apps that are hinged on our sub-features, pointing out good examples of what is already made, and what should be kept out or improved. We ran and compared each functionality separately, while looking at the bigger picture. This provides us with suggestions to combine different things, leaning on the good ideas of bigger/lesser or more complex/simpler projects.

We took 9 apps from the Google Play Store, which were openly categorized as route/location planners and navigation tools, or had features related to those app categories: Just Draw It, Plan My Route, Routin, Zeo, Maplocs, Komoot, Citymapper, Google Maps, and Waze. For good measure, we also experimented with apps related to air quality measurement (Plume, Breezometer), sound monitoring (Hush City), accessibility (Accessible Places Map, Wheelguide), and safety and security (Safe and the City, BSafe).

ONLINE SURVEY

Our target population was selected using a convenience sampling technique and included all individuals that were at least 18 years old at the time the survey was deployed, while agreeing to participate in the study. To ensure data accuracy, respondents that had the survey opened for less than 60 seconds, for more than 2000 seconds, or had an overall response rate less than 33%, were excluded from the study.

The survey included a section of socio-demographic characterization, one regarding mobility preferences and difficulties, and another one regarding perceptions and opinions of the area we defined as Porto's city center. Files were hosted on a private platform and deployed electronically via a link to the University of Porto student mailing list, the Portuguese Foundation of Cardiology, the Portuguese Association for the Disabled, the Portuguese Association for the Blind and Amblyopes, and the Portuguese Association for Asthmatics.

FOCUS GROUP SESSIONS

The main aim of conducting focus group sessions was to gather information about individual perceptions of safety and comfort when walking or cycling, taking into account personal characteristics and specific circumstances of travel. Themes fell into the participants' mobility experiences, factors that could make a route less safe, or limit comfort and accessibility, as well as personal opinions on current route planner apps, and feature exploration. Participants of the focus group were selected by convenience and invited to participate via Zoom meetings. The methodology included a socio-demographic, ethnographic and technology-related questionnaire, in order to perform an ethnographic characterization of the group, followed by semi-structured interviews.

RESULTS

COMPARATIVE ANALYSIS

As far as route planners go, they usually have the same functionalities, slightly changing their appearance, a few interaction paradigms, and the focus on what the main activity is. Komoot's focus is on biking, so it adds a layer of information which is more relevant to those specific users. Citymapper's big upper hand relies on the tight integration with public transportation. Waze is solely directed at motorized vehicles, relying on a crowdsourcing feature for event reporting, and Google Maps is the powerhouse of navigation tools, as it is an all-rounder, feature rich, straight to the point, trendsetter app when it comes to functionality and interface guidelines.

Regarding other features besides the main route planning, we need to know how, and what do other standalone apps feature, that might serve as a guideline or inspiration when integrating those aspects in our work. Plume and Breezometer both have air quality index information presented as heat maps and divided by each type of pollutant, and Hush City is a crowd sourcing app that asks you to go to known quiet (or noisy) spots, record the sound and take a picture, reviewing it. Those pins will then be displayed on a map for other users to consult. Regarding accessibility, both analyzed apps are also crowdsourcing apps in which you can select points of interest on a map and either check their accessibility evaluation or evaluate them yourself by a short survey posed by the app. Safe and the City is an app that integrates safety as a parameter for a journey. You can check pins of safe spots or emergency services, or real time notifications from the police. It has a crowdsourced feature as you can share the safest routes you know, review them with your experience, as well as reporting incidents along the way. BSafe creates a safety network from your contacts, which will then be used for several purposes. The app offers SOS voice activation, without the need of pressing a button, which will share your location with your guardians. GPS tracking and live streaming means that you can invite guardians

to walk with you live or call you and get you out of unpleasant or threatening situations.

All in all, several good ideas can be taken from this analysis. Current apps usually have their strong suits, but in regards to a specific means of transportation (except for Google Maps being an all-rounder) or a specific functionality. To our knowledge, there is no app that can gather, in an all-in-one solution, interesting functionalities from what seems to be as of now, split. A good example is the fact that there are no route planners which take into account noise pollution, or lighting levels as route calculation parameters, or take conditioned mobility in a more serious manner.

ONLINE SURVEY

Our target population included 326 respondents, with 84 being excluded for not matching the selection criteria. Our sample included 242 participants, with 57.1% being female and 46.9% male. The most frequent age range was from 40 to 49 (27%) followed by 30 to 39 (26.6%). Regarding formal education, 83.5% had an ISCED 6 level (Bachelor's or equivalent). Most participants (93.6%) had no limitations to mobility (such as physical impairments or other diseases), but a few (6.4%) considered their use of a baby stroller as a limitation.

These next two questions allowed for multiple choices. The preferred means of transportation (n=392) included the car (33.4%) and the subway (23.7%), with 17.6% of participants travelling on foot. The most common identified obstacles to mobility (n=581) were irregular or damaged pavement 23.4%, vehicles parked on pedestrian zones 20.8%, insufficient parking spaces 19.3% and steep inclines (17.2%).

The set of questions regarding Porto's city center revealed that almost half of the participants has felt unsafe while travelling the area (48.8%), with more than half stating that it has too much car (52.8%) and even pedestrian (70.1%) traffic. A significant percentage of people agrees that it is difficult to find parking spaces (71.2%), and more than half believes that the public transportation system is easy to use (55%).

FOCUS GROUP SESSIONS

Three focus group sessions with eight participants each were conducted online, using the Zoom platform, on different days. Each focus group lasted about 90 minutes.

Our population was gender balanced and mostly within working age (30-50 years old). Formal education level was high, with an above-average technological proficiency. Participants reported adopting multiple commuting forms, with travelling by car having a higher percentage when it comes to transportation preferences for longer commuting. However, the number of people using public transportation, bicycle, and other soft modes for commuting seems to be growing, which could be a chance to invert the overlapping car usage tendency. Smartphone

usage was common (as well as a few smartwatches), and route planning apps were mainly used to determine the route to unknown destinations, quickly obtain the fastest route, or to check if there are any traffic disruptions in their daily commutes.

Participants reported they had felt unsafe when walking, particularly when alone at nighttime journeys, fearing accidents or physical violence. Factors that contribute to the perception of an unsafe route are the absence of people and adequate illumination, lack of surveillance, lack of directions, the environment (e.g., degraded neighborhoods, garbage, surroundings with signs of vandalism), intense automobile flow, not enough sidewalks, or sidewalks with obstacles. Comfort is reduced due to intense people flow, poor air quality and excessive sound pollution, uneven, damaged or slippery pavement, inadequate illumination and steep inclines. Accessibility is affect-ed due to the reduced width of sidewalks, works on public roads, poor placement of urban equipment, and the number of access ramps. When discussing possible features, participants agreed that information about the air quality and noise levels could be interesting, particularly for younger environmentally conscious generations and people with respiratory conditions or travelling by soft modes. Featured data on higher people density on certain areas would be interesting in order to avoid them during the day, but a welcomed setting during nighttime routes. A feature where un-safe areas could be flagged was considered of interest, particularly in countries or areas with higher crime rates, but legal and ethical difficulties of implementation must be thoroughly considered in advance. There is scope to include conditioned mobility, historic/scenic and ecological/quieter routes, each with specific associated parameters, and bearing in mind that they could be conditioned by increases in time or distance, or other associated tradeoffs.

DISCUSSION

The need for a change to sustainable mobility is a given by now, and any tool that can help pushing it forward should be welcomed. However, we need to think about the factors that can hinder this modal change adoption, which are hinged on concepts such as safety, comfort and accessibility. Picking something that people already use to move around and capitalizing on new concepts can be the entry point for providing citizens with new perspectives while moving within urban spaces.

From testing current route planning apps, to performing the focus groups and analyzing the survey, a few takeaways surfaced and combined with potential ideas to implement.

We see route planning, functionality and interface-wise, as rather straightforward around a few different flavors. The approach for adding value to what already exists should be based on increasing route customization power, while still retaining the basics. If we lean on the specific data regarding public transport information, traffic status, weather conditions, lighting levels, air and noise pollution status, people density, and slope levels, we can go beyond the usual time and distance dimensions. More data means more options to define routes. More available and tailored routes trans-lates into a higher chance of fulfilling a user's wants or needs, which may lead

to an incentive to trade personal transportation for sustainable mobility, even if only at times.

Our concept was validated, as participants were interested in the idea of being given personalized routes and be able to access more information about them besides time and distance. Even though the majority of users does not experience limitations, conditioned mobility can be present in several ways, ranging from temporary (pregnancy, baby stroller, crutches) to permanent (old age, health conditions). It should be looked at with more interest, when discovering which parameters can affect the accessibility – crucial (wheelchair) or convenient (baby stroller) – category in some way.

The sense of security, much stressed in these sessions, and being able to plot a route that would prioritize those types of parameters, especially at night, would be a well-received addition. Another suggested feature was showing profile statistics and some type of environmentally themed gamification components such as calories spent, CO2 emissions cut by not driving, or money saved by not using transportation services. Some level of crowd sourced information should also be thought of, regarding the identification of accessibility points (as they are missing from most route planners), or the reporting of events or incidents, such as abnormal crowd levels in specific places, accidents, roadworks and blockages.

We were able to outline which elements could be highlighted on an innovative route planner, regarding safety and security, accessibility, and comfort and well-being. Further studies will rely on building user personas which can illustrate an array of use cases and the definition of key app features. From there, a first approximation of the information architecture can be mapped, which will then be translated into a first prototype and subjected to testing.

ACKNOWLEDGMENTS

This paper is a result of the project Safe Cities - Inovação para Construir Cidades Seguras, with the reference POCI-01-0247-FEDER-041435, co-funded by the European Regional Development Fund (ERDF), through the Operational Programme for Competitiveness and Internationalization (COMPETE 2020), under the PORTUGAL 2020 Partnership

REFERENCES

Baena-Toquero, M. J. et al. (2014). “Towards Sustainability in Multi-Modal Urban Planners.” In 2014 International Conference on Connected Vehicles and Expo, ICCVE 2014 - Proceedings, Software Engineering Department, University of Granada, Granada, Spain, pp. 492–97.

Chowdhury, S. (2019). Role of Gender in the Ridership of Public Transport Routes Involving Transfers. Transportation Research Record, 2673(4), pp. 855-863.

Dell'Asin, G., Monzón, A. and Lopez-Lambas, M. E. (2015). "Key Quality Factors at Urban Interchanges." Proceedings of the Institution of Civil Engineers: Transport 168(4): pp. 326–35.

Eguiluz- Gracia, I. et al. (2020). The need for clean air: The way air pollution and climate change affect allergic rhinitis and asthma. Allergy, 75(9), pp. 2170-2184.

European Commission (2007). Publication of the European Commission Green Paper: Towards a New Culture for Urban Mobility. Available at: https://ec.europa.eu/transport/themes/urban/urban_mobility/green_paper_en (accessed on 27 April 2021).

Franklin, B. A., Brook, R., and Pope III, C. A. (2015). Air pollution and cardiovascular disease. Current problems in cardiology, 40(5), pp. 207-238.

Kiestra, P., Kondo, N. and Clague, C. (2019). Safe Cities Index 2019 Urban security and resilience in an interconnected world. The Economist Intelligence Unit Limited.

Nieuwenhuijsen, M. et al. (2019). Implementing car-free cities: rationale, requirements, barriers and facilitators. In Integrating human health into urban and transport Planning, Springer, Cham, pp. 199-219.

Ortega-Fernández, A., Martín-Rojas, R., and García-Morales, V. J. (2020). Artificial intelligence in the urban environment: Smart cities as models for developing innovation and sustainability. Sustainability, 12(19), p. 7860

Park, Y., and Garcia, M. (2020). Pedestrian safety perception and urban street settings. International journal of sustainable transportation, 14(11), pp. 860-871.

Peña-García, A., Hurtado, A., and Aguilar-Luzón, M. C. (2015). Impact of public lighting on pedestrians' perception of safety and well-being. Safety science, 78, pp. 142-148.

Reames, T. G., and Bravo, M. A. (2019). People, place and pollution: Investigating relationships between air quality perceptions, health concerns, exposure, and individual-and area-level characteristics. Environment international, 122, pp. 244-255.

Ropkins, K., and Tate, J. E. (2021). Early observations on the impact of the COVID-19 lock-down on air quality trends across the UK. Science of The Total Environment, 754, p. 142374.

Santos, P. M. et al. (2018). Porto Living Lab: An IoT-based sensing platform for smart cities. IEEE Internet of Things Journal, 5(2), pp. 523-532.

Shach-Pinsly, D. (2019). Measuring security in the built environment: Evaluating urban vulnerability in a human-scale urban form. Landscape and urban planning, 191, p. 103412.

Silva, D. C., and Silva, A. N. R. (2020). Sustainable modes and violence: perceived safety and exposure to crimes on trips to and from a Brazilian university campus. Journal of Transport & Health, 16, p. 14.

Su, K., Li, J. and Fu, H. (2011) Smart City and the applications. In Proceedings of the International Conferences on Electronics, Communications and Control, Nigbo, China, 9–11 September 2011; pp. 1028–1031

Talari, S. et al. (2017). A review of smart cities based on the internet of things concept. Energies, 10(4), p. 421.

Tsalera, E., Papadakis, A., and Samarakou, M. (2020). Monitoring, profiling and classification of urban environmental noise using sound characteristics and the KNN algorithm. Energy Reports, 6, pp. 223-230.

United Nations. Cities Will Continue to Grow Especially in Developing Countries. Available at: https://bit.ly/2L8Abdc (accessed on 27 April 2021).

Winters, M. et al. (2011). Motivators and deterrents of bicycling: comparing influences on decisions to ride. Transportation, 38(1), pp. 153-168.