Towards Healthier Urban Mobility

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Abstract

As a consequence of the increased dissemination of wireless and location-aware mobile devices, self-monitoring and crowd-sensing has become increasingly popular in recent years. In parallel, discussions about sustainability, air pollution and greenhouse gas emissions have also been intensified.

We propose combining ideas of self-monitoring, crowd-sensing and persuasion towards a real-time city atlas which induces urban dwellers to integrate higher levels of physical activities into their daily mobility needs and to guide their mobility behavior towards a higher degree of sustainability as well as a lower exposure to polluted air.

Author Keywords

Air pollution; crowd-sensing; health atlas; participatory sensing; self-monitoring; urban mobility

ACM Classification Keywords

H.4.2 [Information Systems Applications]: Types of Systems---Decision Support; J.3 [Life and Medical Sciences]---Health, Medical information systems

General Terms

Design, Experimentation, Human Factors, Theory

Introduction
Due to its increase in recent decades, vehicular traffic is considered as a major source of air pollution. The negative impacts on human health of traffic-related air pollution, ranging from difficulty in breathing and nausea up to lung inflammation and increased mortality, are pronounced in urban areas due to a higher density of traffic and affected people [6]. Even at city-level the distribution of air pollutants can vary significantly since the dispersion of pollutants is restricted by obstacles such as buildings. Therefore air pollution hot spots may arise which cannot be captured appropriately by the relatively coarse-meshed network of governmental air quality measuring stations [5].

The exposure to polluted air while being on the move in a city highly depends on the chosen mode of transportation as well as the chosen route. However, as opposed to, for example, differences regarding the exposure to noise pollution, air pollution exposure differences are hard to conceive for the individual. Even at high levels polluted air can be difficult to sense by the human's nose whilst high noise pollution levels can be sensed easily by the human's ears and timely protection is possible by closing the ears manually [5].

When travelling in a city people have diverse transportation modes at their disposal, ranging from public transit over cars to human powered mobility modes such as cycling or walking. These modes differ significantly regarding their energy efficiency and sustainability. They also differ with regard to the exposure to polluted air and the individual's freedom to lower the exposure. Especially the highly sustainable human powered mobility modes play a major role in an urban context since they are best suited for short trips which are predominant in cities. Human powered modes of transportation enable to promote increased physical activeness in combination with daily mobility. Increasing people's physical activity decreases their likelihood of being affected by cardiovascular diseases as well as obesity which also promotes a healthier way of mobility [3].

Several projects have already dealt with crowd-sensing of air pollution using smartphone cameras [1] or small stationary sensors [2]. The dissemination and ubiquity of wireless mobile devices, which are equipped with various sensors and capable of determining their current location, enable a variety of novel possibilities in the fields of self-monitoring, crowd- and participatory-sensing. Small sensors pluggable to mobile devices can extend the opportunities of sensing and monitoring to an even broader range [7, 11]. From an HCI perspective this integration with location-awareness and geography has resulted in the recently established field of Geographic Human-Computer Interaction [4].

Sense and Share
We propose to investigate the interdependencies between urban transportation and health aspects but also whether and how people's mobility decisions can be influenced through an increased awareness of the environmental, energy- and health-related impacts of their chosen modes of transportation. Regarding the health aspects we focus on physical activity and exposure variations to air pollutants depending on the mobility mode. We suggest creating an online service, also accessible through a mobile phone application with persuasive aspects. Such service will combine air pollution data—crowd-sensed by people travelling

within a city—, automated mobility mode detection based on mobile phone sensor data and models describing the environmental impact and energy efficiency depending on transportation mode.

Air Quality

If people can easily sense their exposure to polluted air with mobile devices while being on the move within a city, this will most likely have an impact on their mobility behavior as well as their awareness of air pollution. One could assume that people start exploring the air quality of areas of concern or various routes and transportation modes to get from point A to point B within a city. Increased air pollution awareness may also lead to people questioning their own mobility habits with the resulting impact on air quality.

Communicating the sensed air quality data in real-time to the before mentioned online service can lead to a crowd-sensed city-wide air pollution atlas. In order to have a solid city-wide database the crowd-sensed data stream must be combined with measurements from official air quality measurement stations as well as measurements of small sensing devices placed on public transit vehicles which usually traverse a city on a regular basis [9]. Besides finding minimal exposure routes or searching for places minimally affected by polluted air, the air pollution atlas can be used to assess local spatio-temporal urban air pollution variations. Furthermore such atlas can be used by people on the move to assess their exposure to air pollution. Sensitive demographic groups such as children, allergic people or people with chronic cardiovascular diseases could retrieve customized air quality alerts and suggestions to circumnavigate pollution hot-spots based on their current location.

Transportation Mode & Physical Activity

GPS- and accelerometer data from mobile phones allow for the detection of the current mode of transportation without user interaction. This enables the creation of a personalized profile of the preferred transportation mode. Based on such profile and with the help of corresponding models it will be possible for people to determine their environmental impact and energy efficiency when travelling within a city. Based on accelerometer data the transportation mode profile can be enriched by physical activities involved in the personal daily urban mobility [8].

Induce the Change

We suggest that urban dwellers' mobility patterns can be influenced from two perspectives:

First, confronting people with the facts of their daily mobility in terms of air pollution exposure, the involved level of physical activity as well as the energy efficiency and environmental impact will lead to people critically analyzing their mobility patterns. The process of rethinking one's mobility behavior can be supported by highlighting customized alternatives for daily travels with higher levels of physical activity, lower emission exposures, and increased energy efficiency.

Second, a social-networking component of the service will induce the change of people's mobility by comparing their mobility profiles to others. This comparison also enables a competition with others, e.g., for showing, in terms of air pollution exposure and physical activeness, the healthiest or most sustainable and energy-efficient urban mobility behavior. A social-networking component could also be seen as a good opportunity to disseminate incentives among users such as public transit ticket reductions for car drivers when air pollution concentrations are above a given threshold.

Future Challenges and Outlook

Investigations about the stimuli that encourage people to engage in participatory sensing and using the proposed mobile health service over longer periods leading to the intended behavioral change will be necessary. Another major topic relates to privacy concerns: How private do users perceive their mobility data in general and how comfortable do they feel having mobility activities being tracked and shared with others?

Methods are required for verifying and assessing the reliability of crowd-sensed air pollution data. We also need to address the trade-off between the sensor-based and traditional air quality measuring equipment, such as data capture accuracy of mobile air pollution sensors and spatio-temporal resolution of mobile sensing devices.

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References

[1] Air visibility monitoring. http://www.robotics.usc.edu/~mobilesensing/Projects/AirVisibilityMonitoring

[2] Air Quality Egg. http://www.airqualityegg.wikispaces.com/AirQualityEgg

[3] De Hartog, J. J., Boogaard, H., Nijland, H., Hoek, G. Do the health benefits of cycling outweigh the risks? *Environmental Health Perspectives 118*, 8 (2010), 1109-1116.

[4] Hecht, B., Schöning, J., Haklay, M., Capra, L., Mashhadi, A.J., Terveen, L., Kwan. M-P. (eds.): *Proc. of the GeoHCI Workshop in conjunction with CHI 2013, ACM Press (2013),* 71 p.

[5] Hertel, O., Jensen, S.S, Hvidberg, M., Ketzel, M., Berkowicz, R., Palmgren, F., Wahlin, P., Glasius, M., Loft, S., Vinzents, P., Raaschou-Nielsen, O., Sorensen, M., Bak, H. Assessing the impacts of traffic air pollution on human exposure and health. In: Jensen-Butler, C., Sloth, B., Larsen, M.M., Madsen, B., Nielsen, O.A. (Ed.) *Road Pricing, the Economy and the Environment*, Berlin, Springer (2008), 277-299.

[6] Kampa, M., Castanas E. Human health effects of air pollution. *Environmental Pollution 151*, 2 (2008), 362-367.

[7] Lane, N.D., Miluzzo, E., Lu, H., Peebles, D., Choudhury, T., Campbell, A. T. A survey of mobile phone sensing. *IEEE Communications Magazine 48*, 9 (2010), 140-150

[8] Mun, M., Reddy, S., Shilton, K., Yau, N., Burke, J., Estrin, D., Hansen, M., Howard, E., West, R., Boda, P. PEIR: the personal environmental impact report, as a platform for participatory sensing systems research. In *Proc. MobiSys '09*, ACM Press (2009), 55-68.

[9] Saukh, O., Hasenfratz, D., Thiele, L. Route selection for mobile sensor nodes on public transport networks. *Journal of Ambient Intelligence and Humanized Computing,* Berlin, Springer (2013), 1-15.

[10] Steed, A., Spinello, S., Croxford, B., Greenhalgh, C. E-Science in the Streets: Urban Pollution Monitoring. In *Proc. 2nd UK e-Science All Hands Meeting,* 2003, 36-42

[11] Yoctopuce. http://www.yoctopuce.com