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Interaction design is increasingly about embedding interactive technologies in our built environment; architecture is increasingly about the use of interactive technologies to reimagine and dynamically repurpose our built environment. This forum focuses on this intersection of interaction and architecture. — Mikael Wiberg, Editor

Walking in Smart Cities

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Walking is the collaboration and confluence of body, mind, and place. It has been repeatedly acknowledged as the composing instrument of the city, generating social and urban life; as the most democratic and accessible physical activity; and as a cultural and aesthetic practice, a vital antidepressant, a heart saver, a non-dieting diet, and an antidote to cope with the syndrome of chairs and wheels. The rediscovery of walking may compete in importance with the invention of the wheel [1,2].

Operating from the standpoint that walking is essentially a situated human experience, our aim is to develop a discussion of walking within the context of so-called smart cities. We hope this will initiate a broader multidisciplinary discourse on how to retain and improve the urban walk. Our analytical framework draws on well-established concepts in the broad domain of urban sciences while considering technological enablers in built environments such as pervasive sensing, machine learning, and actuation techniques. By bringing walking and its multidimensionality into focus, we also intend to argue that the challenges in the mission and vision of smart cities extend beyond reform-campaign optimization through data and automation. Future cities that incorporate ambient intelligence and interactivity should be able to respond to the complexity of humans' interactive experiences with and within their environments.

Walking in this context is an

interactive spatio-temporally immersive user experience, a topic of investigation for the branch of ubicomp and HCI research that seeks a transition from the realm of artifacts to the realm of built environments [3]. In the following, we chart the landscape of research surrounding five interconnected themes that we think are crucial to the discourse of walking in future cities. Our aspiration has been to offer visionary directions and reflections, building on what we already could capture from urban sciences about each theme and the concepts associated with it.

THE SOCIAL SCENE OF THE CITY

Public space is the corporeal space and the social scene of the city, the pedestrian realm, where interaction is mostly about spontaneous body management. As a public good, public space is co-produced by its consumers. Just like education, health, and culture, the consumption of public space contributes to its production [4]. The pedestrians produce the public space of the city as they walk through it and as they benefit from the pleasures of being in the crowd.

Insights

- Future cities should be responses to questions that reflect the complexity of human interactive experiences within environments.
- Smart cities should actively avoid the trap of classification, which social media is already suffering from.
- We need to tame micro vehicles in favor of—and to serve, not rival—walking.

Of particular relevance to the discussion of smart cities are the notions of *diversity* and *accessibility*, two essential elements that determine the quality of public space [4]. The production of public space entails the diverse and inclusive participation of those who passingly inhabit it. Therefore, the platforms that cities create should avoid any direction that may lead to physical, financial, or technological barriers or clustered use. In data science, however, there is an inherent desire for clustering. This stems from systems thinking, which often fragments bigger problems into smaller pieces that are easier to approach. There are many data-oriented projects that dangerously employ classification methods to social settings, and particularly to the use of urban spaces. For example, route-planning applications that tune their suggestions based on the outcome of personal profiling algorithms have set their goals, consciously or not, to assign urban spaces to similar profiles—a road to segregation. The vision of smart cities should actively avoid the trap of data classification, which social media is already suffering from and which has created divided sociopolitical circles. This is a user-experience design challenge. How can we translate the urbanite's data to actions, decisions, and presentations that foster diversity and scaffold settings where physical, cultural, and social differences can come together?

WALKING ACROSS AUTONOMOUS VEHICLES

There exists a significant imbalance between the abundance of investment in the research and development of autonomous vehicles (AV) and the status

of the car system in urban sciences. Automobility has been highly criticized for its spatial consequences in cities, alongside ecological and energy concerns. The crux of such critical discourses is that cars privatize the public space and destroy it. With their hard shell and asynchronous speeds, cars encase their users in cocoons of privacy; they impose a system of social and physical segregation to a city, increase regulations, and decrease spontaneity. Car infrastructures create distances that only cars themselves could overcome, repressing the diversity of transportation modes and rendering the environment difficult for those without cars, specifically for those walking.

On the other hand, it would certainly be naive to assume that the market-oriented investment in AVs will by itself increase sharing and decrease the demand for private cars. Building upon previous efforts to transition from car-dominant systems of mobility, research in smart cities should contribute to reducing the absolute number of cars—the most inefficient way of moving around—and to provide time and space for other modes.

From another perspective, the experience of every individual pedestrian in an environment where they have to interact with a cohort of AVs (e.g., zebra crossing line) is at stake [5]. A piece of software code moving heavy, hard masses around our cities at high speed might last as the dominant mental model of AVs for a while. How long it will take for pedestrians to trust AVs' decisions and comfortably share urban spaces with them is a difficult question, the response to which depends on a multitude of factors, such as the functional error rate that they will exhibit in real situations. Trust in artificial intelligence, however, is also a user experience design pursuit. Interaction design research on AVs needs to experiment with new forms of communication with the public that can create the perception of trusted tacit mutual understanding. How can the sensing and actuation infrastructure of smart cities contribute to the dialogue between pedestrians and driverless cars?

THE AGILE FRAGILE MOBILE INDIVIDUAL

Driverless cars are not the only non-human intelligent actors that are expected to emerge, proliferate, and

"Is this how we are going to get around in the city?" Image from Italian weekly newspaper *La Domenica del Corriere* (N. 50, 16 December 1962).

shape new urban mobility regimes. In the past few years, there has been an indisputable resurgence of vehicular units positioned at the micro level of the transportation system (e.g., e-scooter, e-bike, self-balancing personal transporters). The micromobility companies that provide the sharing of electric scooters and bikes, such as Bird and Lime, have begun to forecast higher growth than Uber and Lyft. This is continually enforced by the new generation of batteries and light materials, coinciding with artificial intelligence and connectivity that enable localization, resource allocation, and sharing.

Our position is that micro vehicles, which, unlike cars, can cohabit with pedestrians, should and will populate in new forms and thus carry an

ambitious positive potential for future human-centric cities. They provide an opportunity for urban mobility to go beyond the unsustainable system of automobility and its spatial patterns of segregation and fragmentation. This is, however, not free of challenge; cohabitation is not a given. While the diversity and plurality of micro vehicles and their ability to quickly blend into a walking practice will make pedestrians more agile, they also put those same people in a fragile position: The pedestrians will have to share their spaces with other mobile elements that can be faster than them and stronger physically.

The challenge is to *tame* micro vehicles in favor of and to serve walking—as *walking gadgets* and not as rivals. A desirable ecosystem

accommodates a diversity of modes, which in combination with public transport facilitates agility and offers extended accessibility.

How can smart cities use data to provide an infrastructure for the cohabitation of pedestrians and micro vehicles without imposing hardwired street segmentation and regulation, for example, by constraining the pace of (connected) micro vehicles depending on the recognized context?

WALKING SAVES LIVES

As Aaron Sussman and Ruth Goode write, “The body is built poorly for sitting, only a little better for standing, but it is unrivaled for walking” [2]. Since the early 2000s, a strand of research in medical and behavior sciences, under the banner of Active Mobility, has been striving to tackle physical inactivity problems by taking daily commutes as an opportunity, advocating an alliance between transportation research and public health.

Interestingly, the health gain per unit of energy expenditure is far greater among sedentary people than the already physically active (athletic) ones, implying that much can be achieved in terms of global public health just by bringing a few minutes of walking into daily routines.

Research in interaction design has shown that persuasive technologies can modify individual and collective behavior through the means of situated awareness, enchantment, and ludic personalized incentives. How can smart cities engage their actors in a long-term experience that engenders not only examining walking as a daily activity but also creating a virtuous circle through which walking becomes a sustainable habit? Walking can encourage more walking through the process of training, improvement of skills, and developing intrinsic motivations. This is already exhibited in the quantified self phenomenon: Walking is measured, registered, and shared through social networks; physical effort is valued by and pleasurable for many. Future cities can embrace the motivation for physical effort as an opportunity and provide platforms that facilitate the integration of walking and cycling into mobility

routines [6]. In this regard, intelligent systems that inform the spatial design of smart cities (and ones that simply provide travel trajectories) should go beyond a general premise that assumes people compare different alternatives and make their choices according to the principle of least effort. Rather, walking can be considered a rewarding experience and perceived as positively stimulating.

FROM PRIVACY TO ANONYMITY

The ubiquity of sensing and the bevy of various recording devices in our built environments raise concerns related to data ownership and the ethics of personal data analysis, as well as data protection and privacy. In the context of public spaces and focusing on walking as a social experience, however, data-privacy concerns need to be discussed in relation to *anonymity* and *security*.

Anonymity as an essential characteristic of urban public spaces is correlated with and embedded in their spatial configuration and the social construct. It is the right to be a stranger, a mere momentary consumer/producer of public space. Anonymity protects intimacy, and as opposed to privacy, is possible in the public realm. The more diverse and socially rich the public space, the more anonymity is expected and possible to achieve. How can smart cities guard the right to be anonymous depending on the spatial and social context? At the level of sensing and data anonymization, how can the spatial configuration of the city and the gradient from public to community spaces frame and guide the design of data processing?

Security of pedestrians, particularly in low-density urbanity, is a primary challenge to which smart cities can present notable contributions. Solutions such as adaptive street lighting and hazard-detection algorithms that can couple with personal wearable and mobile sensors are central to how future horizontal cities can advance the experience of walking.

Across the themes discussed here, the trans-scalar role of walking is notable as the fundamental component of urban mobility placed

at the center of different modes, and consequently the human as a locomotive being at the center of what creates the vision of walking in smart cities. This highlights the path for human-centered design: Augmented by seamless information and supported by seven-league boots (macro and micro mobility), citizen-actors become themselves the main infrastructure of the city.

Finally, and once again, we would like to conclude by pronouncing the responsibility of the ubicomp/HCI community to engage in matching the vision of technological possibilities to the setting that they are intended to serve—a perennial crossdisciplinary mission that entails the profound consideration of contextual concerns, many of which have been long studied in the relevant fields, in this case, urban sciences.

ENDNOTES

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