Prospectus

Indoor environmental quality - a data-driven approach to mitigate COVID exposure in indoor spaces

(Technical Topic)

Necessity of Human-Driven Smart Cities

(STS Topic)

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

As individuals begin to return to work among the COVID-19 pandemic, there is still uncertainty about what factors impact potential virus exposure. Apart from social distancing and sanitation, there is little that is done to prevent the spread of disease in most indoor areas. Recent studies have shown that factors like high temperature and high humidity could decrease the likelihood of COVID transmission (Allen & Marr,2020). In order to better adapt to a return towards in-person activities, its vital to understand how room conditions can impact our exposure. Our capstone project aims to utilize environmental sensors to determine specific indoor air quality (IAQ) factors that may link to increased COVID exposure rates. These factors will then be used to develop a user interface for IAQ management for the UVA Hospital that would allow for real-time environmental data visualization.

Our capstone projects use of sensors represents only a small segment of the shift towards smart infrastructure in everyday life. Large tech companies such as IBM and Cisco lead the way in developing smart technology and designing towards an ultimate goal of creating smart cities. Ideally, smart cities leverage information and communication technologies in order to improve city resource management, city operations, and citizen well-being. In many current smart city implementations, corporate involvement outweighs the voices of those who occupy the city. This innovation provides opportunity for improved efficiency, but without substantial constituent input the cities seem to function as more of a corporate investment than the technological utopia it may be claim to be.

Technical Topic

As the COVID-19 pandemic continues and concerns about its spread remain puzzling, there is growing attention to indoor air quality and its impact on not just COVID-19 spread, but human health as well. Through recent research, it has been shown that viral COVID-19 particles can remain suspended in the air for 2 hours or more (Allen & Marr, 2020). This issue is of major concern, especially in hospital systems, where there are high numbers of at-risk patients as well as many potential grounds for disease spreading if systems are not properly maintained and cleaned. In coordination with Professor Arsalan Heydarian, our Capstone team plans on ultimately designing a UI system for the UVA hospital that can inform workers about indoor air quality factors in different spaces. This UI system would allow the hospital to better understand indoor environmental quality and the implications it has on humans and COVID-19 spread within the UVA hospital system. The IAQ factors that will be investigated include air temperature, humidity, CO2 levels as well as non IAQ factors such as ambient light and noise.

The project scope can be split into three main subcategories: research, interviews, and UI design. The research phase of the project involved a deep dive into the current literature on indoor environmental quality as well as on COVID-19. A thorough understanding of these two topics helped the team to better understand what factors are important and what issues should be looked into when interviewing clients and designing the UI system. Factors such as temperature and humidity have potential impacts on COVID-19 half-life (Morris et Al., 2020), and other factors such as CO_2, VOC's, and $PM_{2.5}$'s could be potential indicators of higher risk areas or COVID-19 presence in indoor spaces. Current hospital air quality

management methods are also being looked into, such as mechanical ventilation, filtration, differential pressure control, UVGI disinfection, directional airflow control, and more (Leung, 2006). Through understanding current hospital air quality management methods, the UI system can be better designed to suit hospital workers' needs. Research into HVAC systems and how operations related to these systems (Balgeman, 2020) can impact COVID-19 spread will provide further insight into better management of indoor air quality. While additional research will continue throughout the process, our team has moved past this stage and into the interview phase of the project.

The interview phase involves researching potential users, formulating effective questions, and conducting interviews. While research allows us to get a solid understanding of the problem and potential solutions, interviews provide us new perspectives and information that allow us to better shape our interface for the target audience. Through interviewing individuals from a variety of backgrounds, ranging from nurses to hospital facility managers, better insight into the UI system design can be gained and this will allow for a system that will display more relevant information for hospital system workers. Understanding their daily needs and what type of information will be most helpful will provide our team the necessary information to create a design that is both helpful and user friendly.

The UI design phase involves the actual creation of the product, which will require additionally research into understanding how UI can be designed to minimize user effort. The creation of the UI will likely take on an iterative process to ensure that we are meeting the needs of the hospital workers who will use the design.

STS Topic

According to the World Health Organization (2015), urban areas contained fifty-four percent of the world's population in 2015. This number is projected to increase to 60% in 2030. With this rapid urban population growth, there is an increased emphasis on how cities manage their resources (Chourabi et al., 2012). City leaders looking to solve these problems are presented the potential solution in smart cities, an opportunity to partner with tech giants to leap into the future. The appeal of a "smart city" lies in its claims for innovation and efficiency, however, when developed without informed public input, it could overstep the role of technology in a community. This leads to an oversimplification of city "efficiency" and diminishes the human aspect of the city system.

The term "smart city" first originated in the 1990s in cities that began utilizing information and communications technology (ICTS), and has remained somewhat vague (Söderström et al., 2014). Hollands (2008) states the phrase has "a rather self-congratulatory tendency. The "self-congratulatory tendency" refers to the idea that smart city implementations are viewed as inherently good due to the connotation associated with "smart". However, the idea that technological innovation comes hand in hand with societal improvements for all is not a given. For example, Singapore and San Diego, both early adopters of smart technology, suffered from increasing wage gaps during the peak of their technological growth (Hollands, 2008). While this is only one metric of improvement for the cities, it signals that these smart cities may not be equally addressing the needs of its constituents. As these technologies become more widespread, it's important to

continue exploring these potential misconceptions and flaws in order understand how smart cities can be effectively implemented.

When considering the potential citizen involvement necessary for a successful smart city, it's important to consider what actors are driving this technological progress. Typical, smart city development is driven by the producers, as competing corporations look to offer technological solutions for a plethora of urban issues that may not even need solving (Eurocities, 2012). Kummitha (2018) suggests that most smart cities rely on a techno-driven method (TDM), where the smart technology is pushed into smart cities due to lobbying pressure from large tech companies. While the techno-driven method provides opportunity for rapid growth, it fails to accurately assess the needs of the population and can lead to solutions being implemented for problems that don't exist. Alternatively, the human driven method (HDM) allows for citizens to incorporate technology into society based on its direct needs. Smart cities created with this approach would have the ability to personalize the level of technological immersion necessary for their issues. Despite the apparent advantages of the HDM for overall societal benefit, the TDM is favorable for the tech corporations that rely on revenues from smart technologies such as IBM, who's smart technology operations consist of 25% of the business and 3 billion dollars in revenue (Hollands, 2013).

The conflicting motivations between those who implement the technology (corporations) and those who are said to receive the benefits of this technology (smart city citizens), lead to smart cities that are not properly designed for its people. By researching case studies of smart operations in cities, we can better understand what human-driven initiatives are necessary to cater to the citizens of a

smart city. For example, Boston has centered their smart city initiatives on solving "real problems for real people" through participatory urbanism while resisting costly technological change without benefit, showing that the HDM has viability in the smart city field (*Boston Smart City Playbook — from the Mayor's Office of New Urban Mechanics*, n.d.). On the other hand, Nice, France vies to encourage "innovation to monitor and manage all elements of the city", a much more expansive goal and completely different approach (Arduin et al., 2016). In order to compare the two cities, the metric of "success" can be subjective, but in this research, it will refer to smart operations that seem to improve overall well-being of the citizens. Additionally, these contrasting cities will provide insight into how the city's partnerships with smart technology providers are balanced with its goals of appealing to the needs of the people.

Next Steps

By investigating different case studies on smart city initiatives, I will earn a stronger understanding of the varying successes and failures in the smart city field. Boston and Nice provide two smart cities that are focused on two different ultimate goals, and by continuing research into them, it will bring more clarity in the argument between the two smart city philosophies. It will be important to determine how the voices of the people can be consistently represented over the life cycle of these smart cities. These conclusions will also help fuel my technical research as it will provide new information on how smart technologies can be correctly implemented. These real-life examples offer the evidence necessary to understand how the city, tech provider, citizen relationship can be properly managed in order to create a true "smart city".

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