Inclusive Interventions: Enabling a Smarter Birmingham

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Background: Socio-economic inequity hinders the urbanization of modern cities around the globe. Yet a 'systems approach' to urbanization that accounts for all the forces that comprise a dynamic urban environment has the potential for many positive outcomes. For example, the disparities that currently arise in modern cities related to education, health outcomes, access to amenities and social services, and political and cultural participation. Socio-economic inequality is a driver for such disparities and is generally higher in cities. Consequently, poorly planned expansion can lead to disorganized urban sprawl, poor access to food (so-called food deserts), increased crime, increased pollution, and other negative developments. Planning for urbanization is further challenged in many cities by aging infrastructure in most cities, (American Society of Civil Engineers, in its 2017 Report Card, gave the USA a grade of D+). There is a growing tendency to leave behind sections of the community and, thus, an urgent need to promote the idea of inclusion as a fundamental requirement for security, sustainability, and resilience in urban infrastructure. This is true even for day-to-day living in the future but the downside of current inequity is amplified when the impact of natural disasters (floods, hurricanes, tornados, earthquakes, etc.,) and longer term effects of climate change considered.

To meet this **"grand challenge"** the urban environment must be studied as a system: infrastructure, people and processes (e.g., energy and water distribution, availability of food and healthcare) are interdependent. Cities are complex systems with highly interconnected flows of capital, resources, energy, and people. Failures can cascade through the system leading to economic, social, and environmental disruptions. Using an inclusive systems approach will yield options for intervention that can eliminate or mitigate the consequences of socio-economic inequality and drive the urbanization process toward improved outcomes for all.

Description of the Proposed System: A disruptive socio-technological system that will guide intervention design using a high-resolution, large-scale simulation of the population and infrastructure. The systems approach will produce a secured urban simulation model for Birmingham that integrates prior data (from Census, geographical information system, built-environment records) with real-time updates (from cell-phone communications, cameras on mobile sensor platforms, environmental threat sensors, and ad hoc structural health monitoring systems). As shown in Fig.1, the synthetic population model (**Aim 1**) will be the centerpiece of the integrated system. The model will be used with live stream data (**Aim 2**) to address the key challenges associated with realizing our vision of Inclusive Interventions (**Aim 3**) by evaluating multiple scenarios and evaluating outcomes in the face of adverse forces, thereby creating options for desirable outcomes that are equitable, resilient and sustainable.

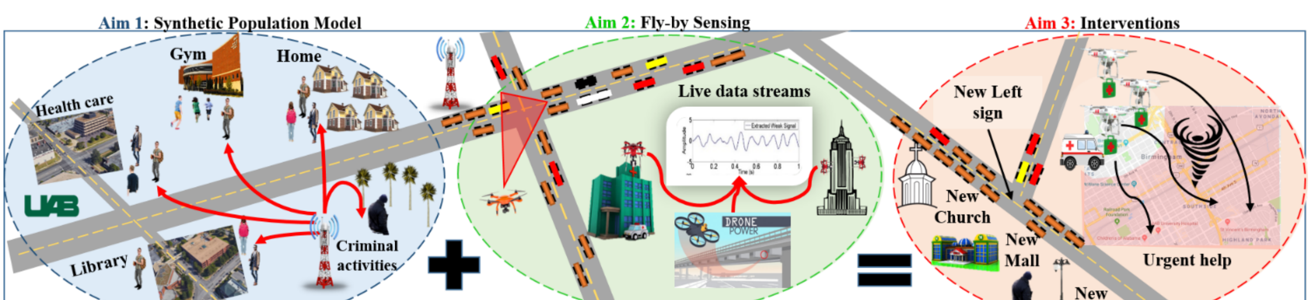

Figure 1. A schematic view of the proposed system

Desired Outcomes: The availability of synthetic living population representation of cities and the agent-based simulations they enable will have transformative effect and induce qualitative change for supporting public policy. City officials, regional planning commissions, and non-governmental organizations concerned with sustainability and resilience will be able to leverage the massive data sets that are currently available in order to reach consensus on desirable policies and interventions. The synthetic living cities data products will facilitate policy informatics for large real-world coevolving social, technical, infrastructure and information networks. The data products can help decision makers understand and prepare for issues such as financial crises, coupled infrastructure systems, natural and man-made disasters, global security, and sustainability problems arising from potential climate change and population growth, pandemic preparedness, just to name a few. It will be a key resource to advance research in the areas of computational epidemiology and computational sustainability.

Work Plan: Current technologies limit officials in responding to challenges with inclusive intervention to eliminate or mitigate the consequences of socio-economic inequality and toward improved outcomes for all. The key advances needed to enable closed-loop, real-time applications of synthetic populations will include **Model** (Aim 1), **Sense** (Aim 2), **Act** (Aim 3), and **Lead** (Aim 4).

Aim 1: Enable large-scale, agent-based synthetic population models calibrated using demographic data (e.g. from the American Community Survey, the National Household Travel Survey, etc.), as illustrated in Fig. 2. These models are open-loop algorithm predicting the response of a population to an event. The objective is to change the population models into a closed-loop feedback system, where live sensors data influence the states of the synthetic population model. Large-scale spatiotemporal models will be used for prediction and analysis of change utilizing both field-based (a continuum or Eulerian viewpoint), and individual-based (a particle or Lagrangian viewpoint) integrated models.

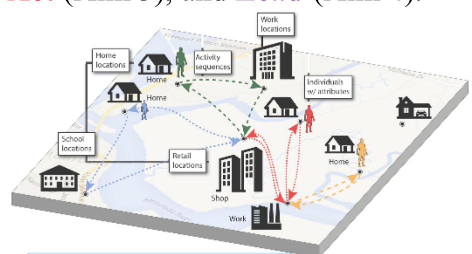

Fig. 2. A synthetic population model

Aim 2: Link synthetic populations to dynamic infrastructure models via rapidly deployable fly-by monitoring (unmanned aerial vehicles, robotics, mobile sensing). We will develop a novel framework for identifying high-dimensional, dynamical systems by using a small number of mobile heterogeneous sensors iteratively redeployed to attain a progressively better model of the underlying dynamics to perform rapid inspection. Although existing sensors can provide most of the information, rapid monitoring is not yet feasible, and so we will innovate new fast algorithms to recommend interventions needed to encourage inclusion, eliminate food deserts, promote diversity, improve physical and mental health by improving infrastructure, and manage traffic congestion, buildings where survivors may safely seek shelter or bridges that an evacuation route can safely cross.

Aim 3: Make synthetic population model and live data actionable by designing inclusive interventions to internal challenges (racial and economic disparities, aging population and infrastructure) and external threats (tornadoes, epidemics, violence etc.), and dispatching limited resources to maximize benefit by risk-based deployment of mobile sensors, first responders, and cells-on-wheels for triage sensing (Fig. 3). For example, deliver the blood, defibrillators or tourniquets and hemostatic supplies to injured in mass shootings, epidemic outbreak, natural or manmade disasters in advance by taking off as soon as the EMS call comes in. Delivering expensive and rarely used drugs, such as antivenin for snakebites, as well as help meeting the demand for blood products in the pre-hospital setting quickly and inexpensively.

Fig. 3. Risk-based resource deployment

Aim 4: Build a foundation to communicate the significance of our work, through development of software platforms, stakeholder communities, and student leaders capable of translating our novel research into practice. *In the process of doing this for Birmingham, we will develop the software pipeline that will support doing the same for other cities and for further extending the representation of each city by allowing more data sets to be layered in with the existing data resource.*

Exhibit A

List of Potential Team Members (individuals and organizations) from inside and outside UAB

UAB Team Member:

Department of Civil, Construction, and Environmental Engineering:
Nasim Uddin, PhD, PE, Professor (Model, UAVs, Infrastructure, Algorithms)

Department of Electrical and Computer Engineering
Mohammed Haider, PhD, Associate Professor (Sensors, Electronics)

Department of Computer Science
Ragib Hasan, PhD, Associate Professor (Data Management, Simulation)

Department of Government
Akhlaque Haque, PhD, Professor (Social Science, Policy)

Department of Emergency Medicine
Kevin S. Barlotta, MD; Medical director of department of critical care transport (Critical Care)

Department of Environmental Health Sciences, School of Public Health
Mischell Fanucchi, PhD, Associate Professor (Public health)

Department of Psychology
Despina Stavrinos, PhD, Assistant Professor (Infrastructure and Psychology)

Outside UAB Team Members:

DYNETICS, Huntsville, AL
Baron Johnson, PhD, (Baron.Johnson@dynetics.com) (UAS Aerospace Section Manager), AL

IBM Software Group
Ashish Cowlagi, PhD, (ashishc@us.ibm.com) (Government Solution & Smart Cities), Armonk, NY

City of Birmingham
John G. Colon (Director of Department of Community Development), Birmingham, AL

Biocomplexity Institute, Virginia Tech
Samarth Swarup, PhD, (swarup@bi.vt.edu), Assistant Professor (Network Dynamics and Simulation Science)

Tufts University, Boston, MA
Jason Rife, PhD, (jason.rife@tufts.edu), Associate Professor (Robotics, Drones))