NRI: FND: The Urban Design and Policy Implications of Ubiquitous Robots and Navigation Safety

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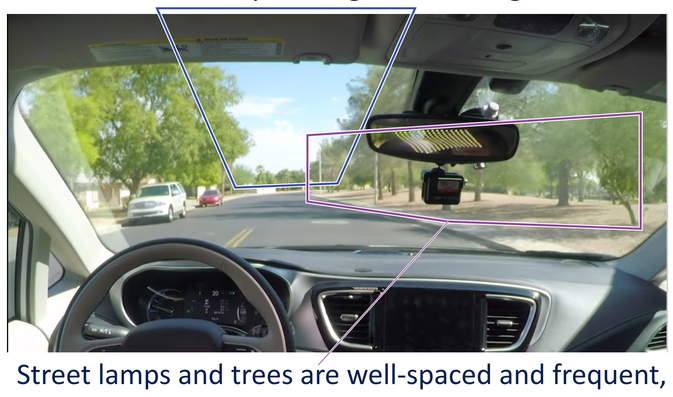
Ubiquitous co-robots offer society a unique opportunity to reshape our transportation infrastructure.

To do this, we must balance the needs of safety, usability, and aesthetics. This research will investigate these tradeoffs in an effort to understand how to turn 20th-century transportation infrastructure (e.g. highways, intersections, roads, sidewalks) into 21st century human infrastructure that addresses the needs of the entire community. Broader questions include:

1) How do we balance co-robot safety with other broader societal needs?
2) How can urban design convey a sense of trust to the public as they operate near co-robots?
3) How can we ensure that all stakeholders benefit from the presence of ubiquitous robots?
4) What architectural features can be added or removed from the streetscape to improve overall safety?

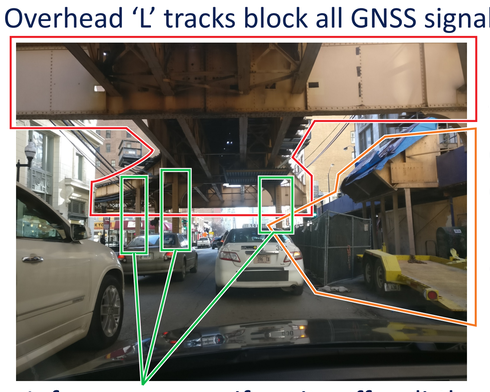
A comparison of a view from a Waymo autonomous vehicle near Phoenix, AZ (left) and Wells St. in Chicago, IL (right) represents the difficulties of robot localization in an urban setting

Unobstructed sky offers good GNSS signals



Street lamps and trees are well-spaced and frequent, offering good potential for navigation safety

Overhead 'L' tracks block all GNSS signals

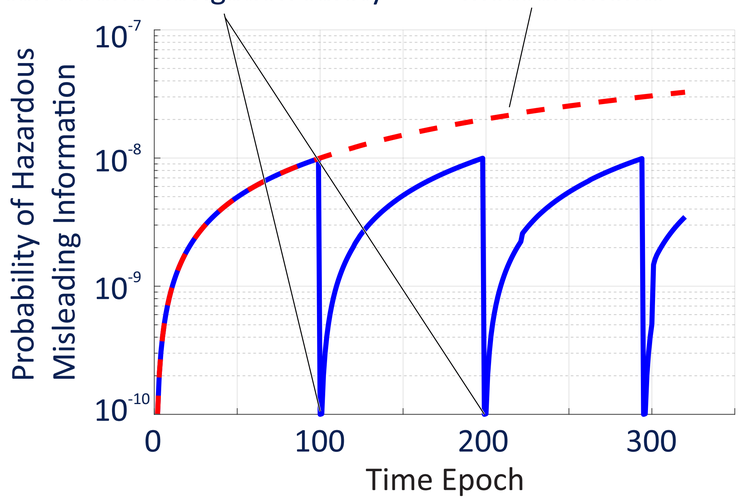


Temporary construction obscures lightposts and other potential landmarks

Infrastructure uniformity offers little differentiation, results in poor integrity

Periodic resets with unambiguous landmarks can bound navigation safety

Integrity risk grows because prior faults affect current measurements



MOTIVATION

1) How can we ensure that landmarks are unambiguously identifiable?
2) What are the possible physical/architectural embodiments of such landmarks?
3) How can we determine the density of landmarks needed to ensure a desired level of integrity?
4) Can modern urban design concepts be leveraged to shape the environment for these purposes?

(Left) Current-time navigation integrity risk depends on past-time faults, which poses a significant problem since the risk can grow unbounded over time. However, if the co-robot periodically encounters known, unambiguous landmarks, integrity risk can essentially be "reset" to a negligibly small probability.

RESEARCH STEPS

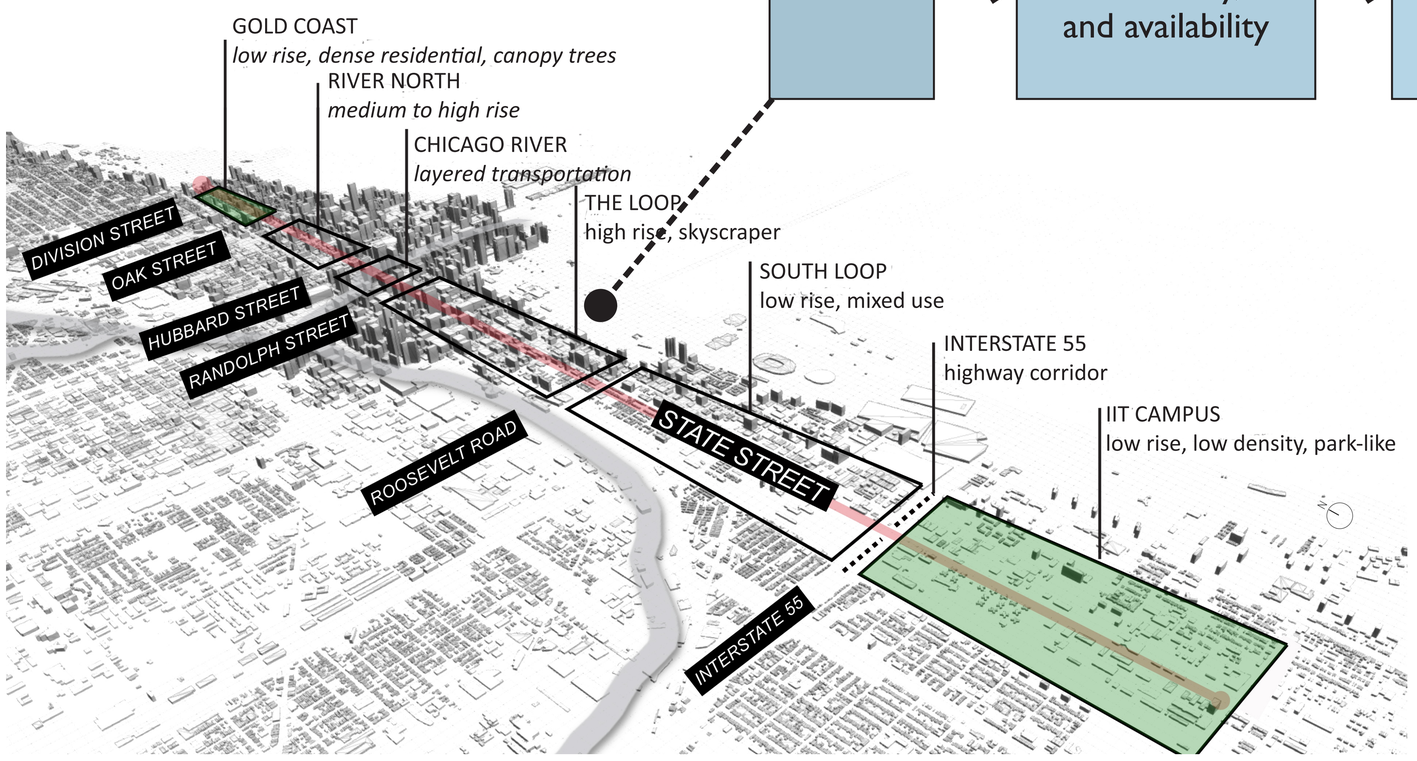
Step 1 Map test site

Step 2 Evaluate integrity, continuity, and availability

Step 3 Develop and validate simulation environment

Step 4 Modify streetscape in simulation to understand impacts on urban design and navigation safety

Step 5 Develop algorithms to improve navigation safety through intelligent landscape modifications



FORWARD ERROR CORRECTING CODE addresses local landmarks (trees) to unambiguously localize an autonomous vehicle moving left to right. A lidar detects the presence or absence of trees and assigns a bit. The last eight bits serve as a unique identifier for a single specific tree. For simplicity, we consider trees on the only on one side of the road.