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Self-Repairing Cities: Balancing the impact of City Infrastructure Engineering on Natural systems using Robots

ASSESSING THE UNDERWORLD

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Programme Overview

Between now and 2050, the United Nations' Department of Economic and Social Affairs estimates that the proportion of the UK population living in cities will increase from 80% to 86%. This is part of a worldwide trend, as cities become home for most of the world's population. Quality of life for future citizens is critically dependent on infrastructure systems that provide water, gas, electricity, transport etc. These interact with natural systems that provide clean air, biodiversity, waste disposal, recycling, and other associated services.

Today's methods of updating infrastructure are resource- and labour-intensive. Much infrastructure is either buried or elevated along our roads and streets. Heavy vehicles in cities produce socially and environmentally damaging air, noise and waste pollution; earth excavation causes transport delays and displaces animal and plant life; maintaining systems 'at height' (lighting, gantries) involves multiple health and safety challenges. Yet often the basic demands of individual maintenance tasks are quite small (requiring few parts, tools and low forces). It is the involvement of humans that makes them expensive, time consuming and disruptive.

Our vision is that of a city where infrastructure is autonomously maintained and dynamically responsive to secure the health & wellbeing of its citizens, contribute to flourishing and sustainable natural systems, and create positive economic and societal outlook. Cities of the future will be more like urban forests, unobtrusively looking after themselves and providing a sustainable ecosystem for their inhabitants in harmony with nature. Towards this vision we propose a Grand Challenge to rid our cities of the socially and environmentally damaging air, noise, light and waste pollution that occurs from infrastructure maintenance associated with roads.

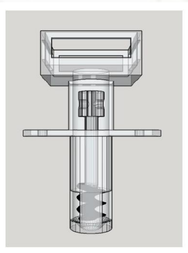
Perch and Repair

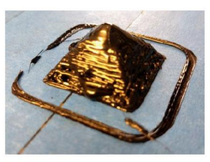
This aspect of S-RC is exploring the use of UAVs to eradicate the potential safety risk of a person working at high elevation as well as removing the need for heavy machinery such as an elevated work platforms.

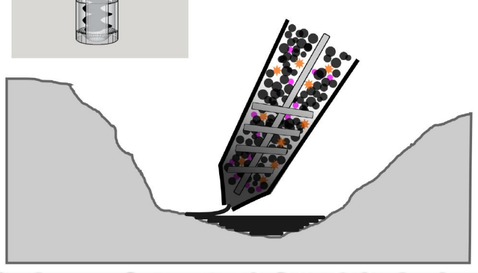
This includes remote maintenance and modernization of lighting columns to promote their use as multifunctional platforms for city communication nodes.

A use case is for UAVs to perform street lamp maintenance. In comparison to modern manual maintenance of street lamps that require cherry pickers, such UAVs in operation will dramatically reduce the cost and safety risks for the tasks. It is useful for tasks that have to be carried out in remote locations, due to the significant safety risks to people and the difficulties of access by ground vehicles.

Perceive and Patch







Swarms of vehicles can perform autonomous inspection and maintenance of city infrastructure. UAVs with dedicated sensors and computers can be trained to identify road defects and its location. Early identification of cracks will allow for targeted sealing to prevent water ingress, the key to preventing the formation of future potholes.

A 3D asphalt printer drone enables automated rapid delivery and repair of road surface defects with minimal disruption to traffic flow, without the risk to human workers on hazardous environments.

Fire and Forget

Robots in cities will need to operate continuously, providing and collecting data in real-time in the future. In this project we are focussing on two main challenges, namely autonomy and battery life. A significant obstacle to long-term operation is the restrictions that short battery life present, which impose the need to have redundant units that can either replace each other whilst the other one is charging or capable of on-the-move charging.

Charging can happen in docking stations on-site, or off-site by retrieving and recharging. In some instances, retrieval may not be feasible. In constrained spaces where space for charging stations or retrieval is undesired, on-the-move charging is preferred.

Future Work

- Self-Repairing Cities has identified new applications for robots in the infrastructure lifecycle of construction, maintenance and decommissioning.
- The key enabler of the radical changes to practice offered by robots is an evidence base for this change (via our research), provision of data and a support system for decision-making .

Fire and Forget

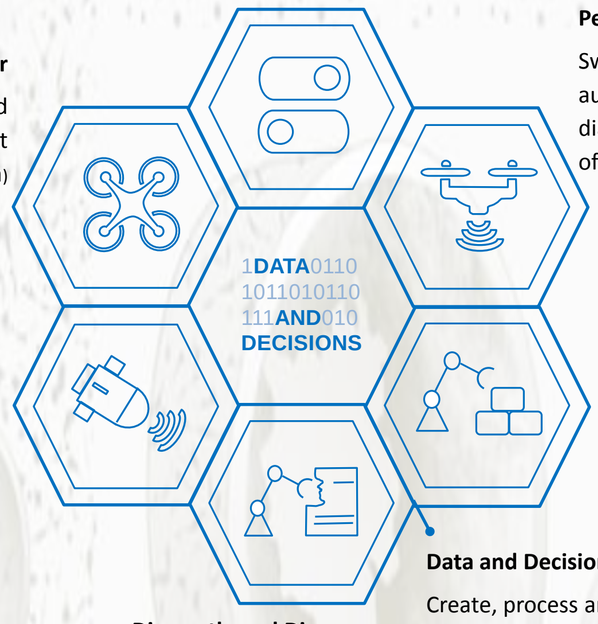
Robots designed to operate indefinitely, performing inspection, repair, metering and reporting tasks (e.g. robots operating in live water mains)

Perch and Repair

Remote inspection and maintenance of structures at height (e.g. bridge inspection)

Plunge and Protect

Autonomous robots with the ability to perform underwater or underground infrastructure inspection, repair, and preventive defect maintenance.



Perceive and Patch

Swarms of vehicles for autonomous inspection, diagnostics, repair and prevention of defects (e.g. potholes)

Construct and Confirm

Coordination of robot teams to build/print, finish and certify infrastructure from CAD models using environmentally friendly building materials.

Data and Decisions

Create, process and interpret data for effective, verifiable and trustworthy operation of robots interfaced through advanced communications with the smart city (e.g. robots to remotely augment building information models through the cloud)

Dismantle and Dispose

Advanced manipulation in extreme environments to manipulate, cut, separate, and unfasten structures (e.g. nuclear de-commissioning)

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