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Title: Simple and Accurate Positioning to Enable Vehicle Autonomy in Underground Mines

Organization: Oregon State University

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Topic: Remote-Controlled, Autonomous, or Smart Machine Design

Concept Summary: While the need for autonomous vehicles in underground mines is well documented, a key technological component toward this - accurate, real-time positioning - is still lacking. Effective positioning in underground mines is a challenging problem due to unique environmental characteristics such as elaborate signal propagation and difficulties associated with establishing sufficient information technology (IT) infrastructure.

Today's location technologies are still far from being able to successfully navigate autonomous vehicles in underground mines: 1) Accuracy: The simplest technologies, received signal strength (RSS) of radio frequency (RF) signals and RFID, simply do not provide the accuracy required to enable autonomous vehicles; 2) Deployment and maintenance complexity: Very few RF location technologies can support the decimeter-level accuracy required by this application. Other solutions such as LIDAR require excessive computational power, which makes real-time tracking difficult; 3) Real-time multi-object positioning: While many systems claim to support simultaneous positioning of many objects, it is often at the expenses of significantly reduced location update rates. This renders them ineffective at guiding many machines simultaneously.

This project builds upon the PI's 15 years of indoor positioning research that has resulted in a simple, accurate, and easy-to-maintain technology (demo video available: web.engr.oregonstate.edu/~hliu/IPS.mp4). This project aims to complete a proof-of-concept (PoC) system that will enable autonomous vehicles for underground mining. The technology has the following features: a) Decimeter-level accuracy, real-time (location update rate as high as 30Hz), and multi-tag capable (up to 100 simultaneously in the same space) positioning with a mere 40MHz RF bandwidth, a small fraction of what is needed by UWB; b) Synchronization of the anchors is not needed, making the system easy to deploy and maintain. c) Long range (>50m between anchors), so that anchors do not need to be densely deployed.

In the PoC system, one or more battery-powered, badge-sized tags that emit a localization RF signal will be attached to each vehicle. The transmitted signals are received by the independently operating anchors, which send their data wirelessly to a location server. The server runs a custom algorithm to determine the vehicles' precise locations and then send their locations to the vehicle for real-time control/guidance.

The project team will collaborate with Oregon State University Robotics Club (https://osurobotics.club/) to test out the PoC system with the club's international-award-wining aerial and mars-rover vehicles in an emulated mine environment. The core positioning algorithms for the PoC system are available from the project team's existing work; further research will be required to adapt the technology for this application. Remaining tasks include (i) a communications interface with vehicles, (ii) a complete set of hardware (anchors and tags), (iii) a location-guided vehicle control interface in the location server (to remotely program each vehicle's moving trajectory and its tasks at each location of interest along its path).

At the end of the PoC phase, a vehicle guided by a high-precision RF localization system will be completed and tested. With additional funding, we anticipate being able to complete a pre-commercial, working prototype vehicles that can be deployed in actual mines. The resulting technology will not only be a key component to enable autonomous vehicles in underground mines, but will also be invaluable for inventory tracking, object identification, and personnel safety.