SMARTPIG and PIGPEN: Long-term SLAM with a downward looking camera

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We can give a robot cameras to see, but they lack the natural capacity to learn from these observations. Walking down the street, a person uses their sight to build a map of the environment: noting where they are, considering if they’ve been there before, and constantly watching for unexpected changes and interesting events. For the last 20 years, this desire to have a robot learn as it explores has driven the development of Simultaneous Localization and Mapping (SLAM) --- having a robot build a model of the world around it while also determining its place in that world.

Historically, SLAM development has focused on a robot's initial forays into a new environment: start from a blank slate, then map and explore. Our growing confidence in SLAM algorithms now lets us consider the robot's behavior in the long-term: given this carefully-constructed map of the world and what it sees now, where is it? Is it someplace new that should be added to the map? Has the world changed and how should the map be updated to reflect that change?

With the switch to long-term SLAM, the robot's map becomes not just a spatial record of what it has seen, but also a temporal record of how the environment has changed. It also gives the robot a reliable, persistent sense of its place in the world not just in an abstract coordinate system, but relative to the sensed environment.
This seminar describes an approach to long-term SLAM for a hovering vehicle with a single downward-looking camera. It first details SMARTPIG (Simultaneous Mosaicking And Resectioning Through Planar Image Graphs), a SLAM algorithm specialized for high-resolution images of an approximately planar surface, such as aerial photographs. SMARTPIG is then extended into PIGPEN (Planar Image Graphs for PErsistent Navigation) by the introduction of the featurescape, a new data abstraction for the long-term storage of visual point features.

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