Hybrid Training Methods for Visual Classification and Autonomous Navigation

S&T Campaign: Information Sciences
System Intelligence and Intelligent Systems

Maggie Wigness, (301-394-5616) 456-0000
maggie.b.wigness.ctr@mail.mil

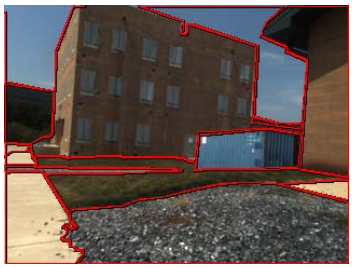
Research Objective

- **Reduce labeling effort using unsupervised learning to efficiently train terrain and object classifiers for autonomous robot navigation.**
- **Autonomous robot navigation using visual classification: traversal on road terrain while avoiding lethal objects.**

Autonomous waypoint navigation performed where road terrain is specified as the only navigable path.

Challenges

- **Visual classifiers need large amounts of labeled data.**
- **Limited time and resources available to assign labels.**



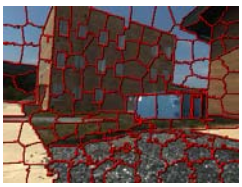
Example of a fully supervised labeling approach where an annotator much outline and provide a label for each unique region in the environment. This takes roughly 7 minutes per image, which requires over 29 hours of effort for small datasets of 250 images.

- **Group labeling introduces a trade-off between labeling efficiency and label accuracy.**

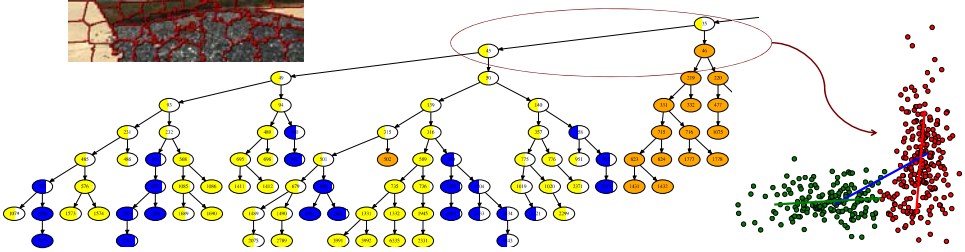
Unsupervised grouping can result in multiple classes being organized into the same group because they share common feature patterns. Assigning a single label to groups that span multiple classes can create significant label noise for the supervised classifier.

ARL Facilities and Capabilities Available to Support Collaborative Research

- **Expertise: Developed Hierarchical Cluster Guided Labeling (HCGL)[1] – unsupervised pattern recognition labeling framework**
  - Hierarchically group over-segmented regions from images.
  - Compute the angle between groups in the hierarchy using the primary direction of variance to model concept transitions and label groups.

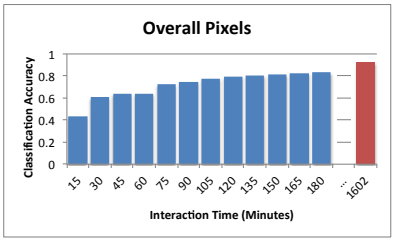


Example of an over-segmented image. The set of red outlined regions from all images is used to construct the hierarchy.



Left: Subset of a hierarchical clustering structure produced by HCGL. Each node color indicates the dominating terrain/object class. Right: Illustration of the primary direction of variance for a parent and child relationship in the hierarchy (red oval). The angle between the blue vector (parent node) and the red and green vectors (children) is computed for the group selection criteria.

- **Reduce labeling effort by a factor of ten to create reliable cost maps**



Left: Iterative classification achieved using HCGL compared to a fully supervised approach (red bar). HCGL achieves similar classification accuracy with only one-tenth the labeling effort. Right: Map produced from visual classification used for autonomous navigation. Dark regions: classified as non-traversable terrain (grass). Light regions: classified as traversable road terrain

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- **Perform further live robot navigation experiments at ALC and Fort Indian Town Gap.**
- **Collaborate to investigate online and adaptive strategies that discover and label new visual concepts during exploration of local environments.**

Publications

1. *Efficient Label Collection of Unlabeled Image Datasets.*, M. Wigness, B. Draper, R. Beveridge. Computer Vision and Pattern Recognition, 2015.

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED