Robust Trail Segmentation and Tracking Based on Color

Yan Lu, Mehmet Kocamaz, and Christopher Rasmussen

Dynamic Vision Lab, Computer and Information Sciences
University of Delaware, Delaware, U.S.A

Robust Trail Following

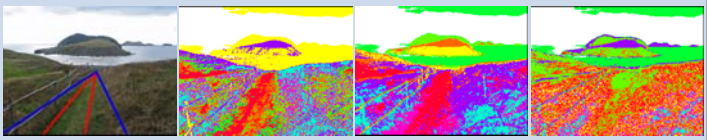
We report on recent advances in our vision-based robotic trail following system. This poster presents preliminary work on:

- A fast image-based algorithm for coarsely finding and tracking trails with no a priori appearance information
- Adaptive selection of color cues to maximize confidence
- Superpixel-based shape refinement of initial triangular trail region estimates
- Classification of images as containing/not-containing a trail region

Examples of trail types:

Trail Appearance Likelihood

- A hypothetical trail region's appearance likelihood is proportional to its (1) color/brightness contrast with left & right background regions and (2) symmetry between those regions
- Multiple features or *cues* are computed at every pixel; here we consider 3 possibilities from CIE-LAB color space: LAB, AB (chromaticity only), and L (brightness only)
- K-means clustering is performed on valid features (under- and over-saturated pixels are excluded) to identify a small number (k = 8 for these results) of common color *textons*



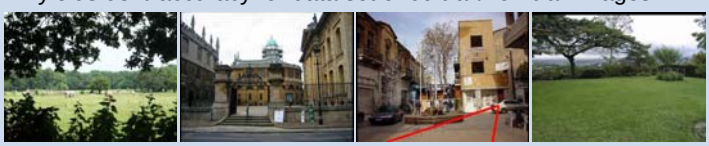
Trail triangle **LAB textons** **AB** **L**

- The distribution of textons within a region is modeled by a histogram, allowing use of standard histogram metrics (e.g., chi-squared distance) to quantify contrast and symmetry
- Given a hypothetical trail region T with histogram H_T, its appearance likelihood is:

$$L_{appear}(T) = \frac{\chi^2(H_T, H_{T_L}) + \chi^2(H_T, H_{T_R}) + (1 - \chi^2(H_{T_L}, H_{T_R}))}{3}$$

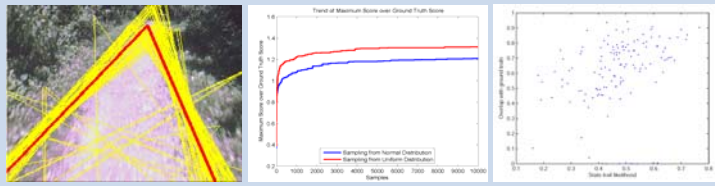
Trail Image Classification

- Threshold on best trail appearance likelihood found can be used to classify whether image contains trail or not. A value of 0.57 yields 93% accuracy for data set of 60 trail/non-trail images



Trail Detection & Tracking

- Trail region shape under perspective often well-approximated by a triangle, so search by directly hypothesizing triangular regions
- Triangle regions are sampled from 4-D uniform distribution with constraints on apex location, bottom width
- Trail likelihood is iteratively maximized via *particle filtering*, modified to switch between cues yielding highest likelihood



Single Image Results

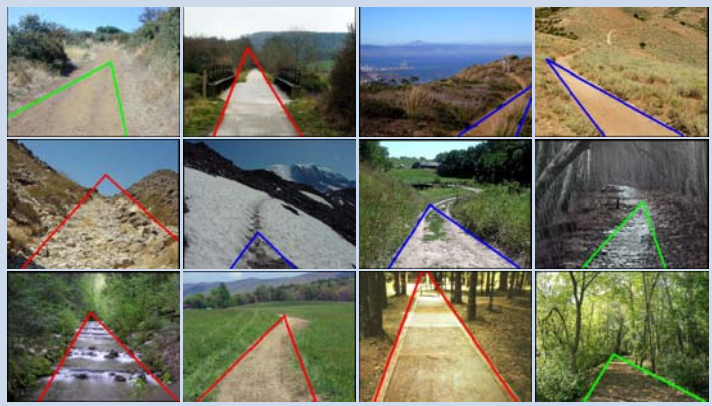
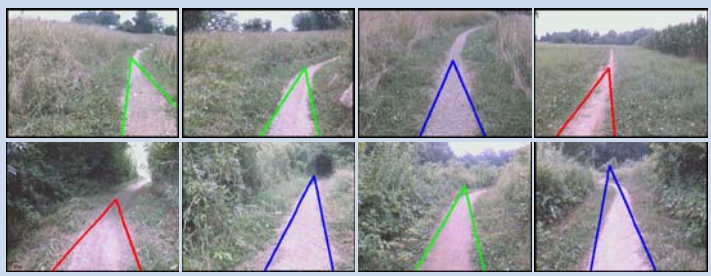


Image Sequence Results



Conclusions

- The method described is near-real-time and works well over a wide range of trail types and illumination conditions. We are currently investigating several extensions, including:

(1) Incorporating trail color into the tracker state

(2) Integrating ladar data into the trail likelihood function

(3) Visual and ladar-based detection of in-trail obstacles

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