Incremental Topological Mapping Using Omnidirectional Vision.

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Why You Should Stay And Listen

- Topological mapping using **ONLY** vision
- Uses local features, so **robust** to occlusions
- Incremental algorithm
  (approximately **linear** time)
The Topological Map

- Precise location unimportant
- Connections important
- A place ~ a node
- A connection ~ a link
- Path planning
A robot equipped with an omni-directional camera takes snapshots of the environment as it moves around. The algorithm processes the images, and constructs a topological map consisting of

- nodes
- weak links
- strong links
What is a node?

**Definition:** A *node* is a collection of *consecutive* images that are "similar enough".

We use a variant of the Scale-Invariant Feature Transform (SIFT) to compare distinctive points in the images. The total number of similar features ("feature matches") is a measure of how similar the images are.
A match is considered if the smallest Euclidean distance (between keypoint descriptors) is considerably smaller than the next smallest distance.
The Incremental Approach

Acquire new image

Extract features (SIFT)

Is image in current node?

Yes

Add image to node

No

Create new node
The affinity matrix is a representation of the similarity between the images.

For \( n \) images, the affinity matrix has \( n^2 \) entries, of which \( n(n-1)/2 \) are unique.

Evaluating the entire matrix to find loops is not feasible in an incremental algorithm.
Heuristic Search

Maximum number of comparisons at each time step (each comparison is an entry in the affinity matrix)

Evaluate entries in the affinity matrix, using a random, heuristic search that...

- ...searches more closely around high-value entries
- ...searches less frequent in low-value areas
Summary of the Algorithm

Preprocessing
- Acquire image
- Extract SIFT features
  - Feature database

Link detection
- Select images to compare
- Compare images
- Affinity matrix
- Calculate link likelihood

Node computation
- Is image in current node?
  - Add image to current node
  - Create node
    - Select next image
- Node database
Results

"Batch" algorithm

103 nodes, 233 strong links

All entries in the affinity matrix computed.

Incremental algorithm

103 nodes, 59 strong links

30 comparisons per added image = 10% of affinity matrix computed.
Summary

- Incremental topological mapping:
  - Clustering images
  - Partial evaluation of the affinity matrix

Left-out contents

- Node representative
- Link likelihood
Future work

- Node merges
- Geometric constraints (RANSAC)
- Better hardware (high resolution images)
Thank You!

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