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ONLINE MULTI-MODEL PARTICLE FILTER-BASED TRACKING TO STUDY BEDLOAD TRANSPORT

Hugo Lafaye de Micheaux1,2*, Christophe Ducottet1 and Philippe Frey2

1Université Lyon, UJM-Saint-Étienne, CNRS, UMR5516, Laboratoire Hubert Curien, Saint-Etienne, France
2Université Grenoble Alpes, Istra, UT ETGR, Saint-Martin-d’Hères, France
*E-mail: hugo.lafaye-de-micheaux@irstea.fr

1. Context & Objectives
Global aim: studying bedload transport thanks to experiments with two-size beads in a water flow.

- Main objective: track beads over long time sequences to better understand size segregation responsible for complex morphology structures.

The idea: propose an online particle filter-based algorithm integrating several improvements:
1. Include an adapted multiple motion models
   - with known mechanical dynamics to better anticipate bead locations.
2. Exploit detector confidence to handle missing detections.

2. Experimental setup

3. Multi-model tracking algorithm

Stage 1: Object detector
- Use specific morphological operations (hconvex, cross-correlation, ...)
- Exploit detector confidence to handle miss-detections (based on [2])

Stage 2: Data association
- Perform greedy algorithm on matching costs

Stage 3: Particle filtering
- Principle: use Sequential Importance Resampling (SIR) with an internal state including motion state, position (x,y) and velocity (u,v)
  1. Draw a new state according to conditional probability table
  2. Propagate the particles using a motion-based stochastic tracking (as in [3]) with 3 motion models:
    - Resting - not moving
    - Rolling - sliding on other
    - Saltating - bouncing on others
  3. Compute particle weighting
  4. Normalize weights and resample particles with SIR method
  5. Estimate position and velocity by averaging resampled particles

4. Results

- Creation of a ground truth dataset of 1000 images for the tests
- Parameters are fixed on half of the dataset

- Tracking evaluation results on 3 algorithm configurations:
  - Algo. Models: % Correct Tracks, MOTP, FN, FP, Id Sw., MOTA
    - 3MM: 98.35%, 0.64px, 0.07%, 0.16%, 4, 99.77%
    - LVM [2]: 95.05%, 0.77px, 0.09%, 0.17%, 23, 99.72%
    - INVM: 89.90%, 0.89px, 0.14%, 0.54%, 84, 99.28%
  - 3MM = 3 motion models ; LVM = 1 constant velocity model ; INVM = 1 null velocity model

- Precision score MOTP according to motion state:

- Correct tracks and MOTP for different detection thresholds:

5. Conclusions & Perspectives

- New online particle filter-based tracking algorithm based on multiple dynamic models:
  - Input of object mechanical dynamics helps approaching real trajectories.
  - Allows studying bedload transport with higher confidence.

- Our multiple motion model based algorithm provides high tracking precision and accuracy with different detector qualities:
  - Outperforms single dynamic models.
  - Effect of inaccurate detections reduced by detector confidence.

Perspectives: Use configuration and state of neighboring objects as an information to help choosing between motion states.

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References