Center for Research in Intelligent Systems

UC RIVERSIDE
UNIVERSITY OF CALIFORNIA

# Real-Time Pedestrian Tracking with Bacterial Foraging Optimization

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9th Annual HUMIES Awards
GECCO 2012

# The Problem

- **Track multiple pedestrians in low-resolution video**
- **Challenges include:**
  - Change in appearance
  - Non-uniform lighting, shadows
  - Uncalibrated cameras
- **Extremely useful for:**
  - Security and surveillance applications
  - Human-computer interaction

# Bacterial Foraging Optimization (BFO)

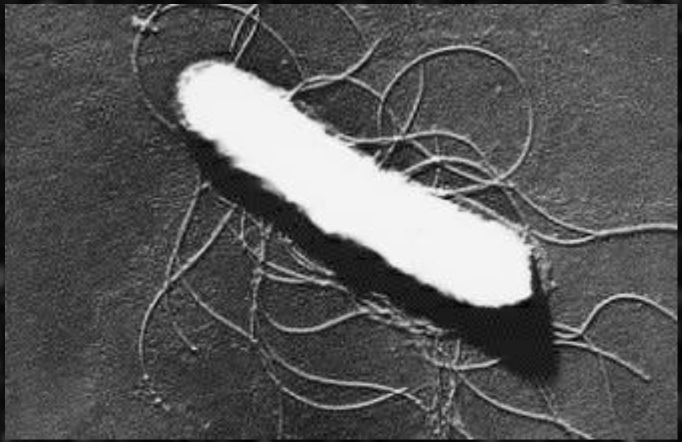
[Passino, MCS'02]

- Swarm intelligence algorithm modeled after foraging behavior of E. coli bacteria

Example: **Searching for a red object**

# Foraging Behavior of E. coli

- Motile strains possess flagellum to “swim”
- “Tumbling” orients the bacterium into a random direction
- The bacterium swims in this direction and continues to as long as the concentration of food increases



# Bacterial Foraging Optimization

- Randomly initialize ***n*** agents on the image
- For each frame, do ***k*** reproduction steps:
  - Do ***j*** chemotactic steps:
    - For each agent ***i***, do this:
      - Evaluate fitness function at current location
      - Choose a random direction
      - For up to $N_s$ times for this agent:
        - Swim forward in a step of size ***C*** pixels
        - Evaluate new fitness
        - If new fitness is worse than old fitness, stop swimming
  - Sort agents by current fitness
  - Relocate $S_r$ worst agents to position of $S_r$ top agents
- Dispersal: randomly relocate agents with a $p_{ed}$% probability to a new random position in the image

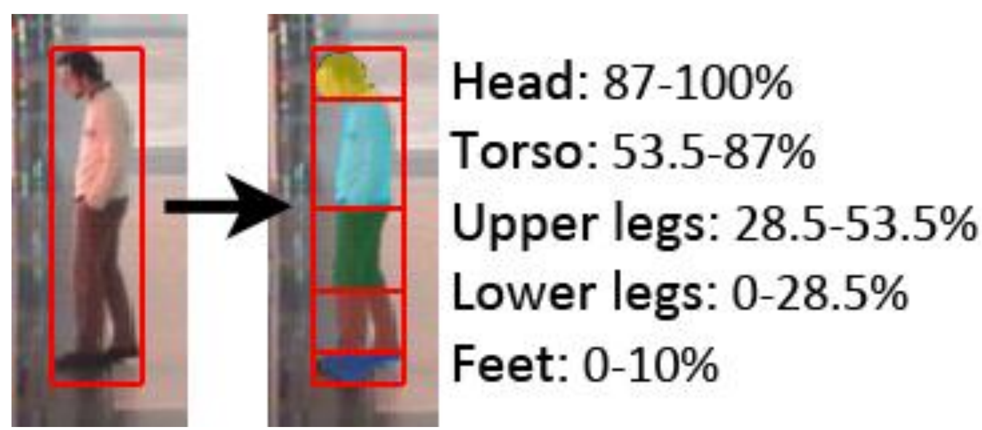
* H.T. Nguyen and B. Bhanu. Real-Time Pedestrian Tracking with Bacterial Foraging Optimization. IEEE International Conference on Advanced Video and Signal-Based Surveillance (AVSS), 2012.

# Improvements for Tracking

- Agents move 1 step forward and then evaluate, continuing if fitness stays constant or gets better, or stopping if worse
  - **Introduced *Lookahead***
- In the same frame, all agents move at every reproduction step, including top agents of the previous iteration
  - **Introduced *Elitism***
- Even if an object stops moving or does not move very far across frames, a full search is conducted every time
  - **Introduced *Early Termination***

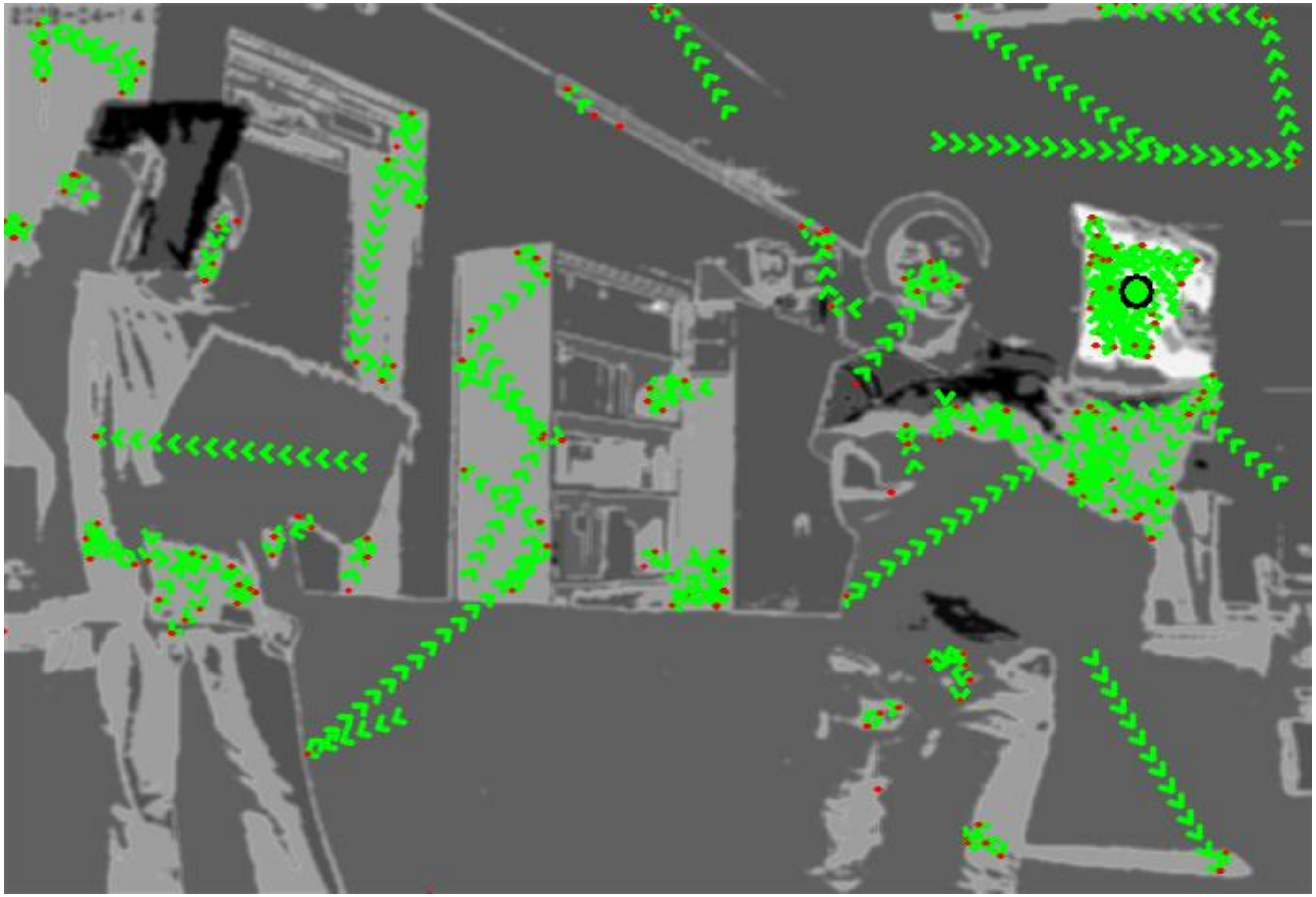
# Initialization

- Detect head and shoulders using Viola-Jones framework or Omega-shape detector
- Extend rectangle of interest (ROI) down to estimate entire body (e.g., height = height*3.1)
- Segment body and create target signature

# Visualizing the Fitness Space

# Swarm's Behavior in Fitness Space



BFO = fast stochastic gradient hill climbing

**darker** = lower fitness,   *brighter* = higher fitness

# Experiments

$$is\_tracked(ROI_{query}, ROI_{gt}) = \frac{ROI_{query} \cap ROI_{gt}}{ROI_{query} \cup ROI_{gt}} > 0.50$$

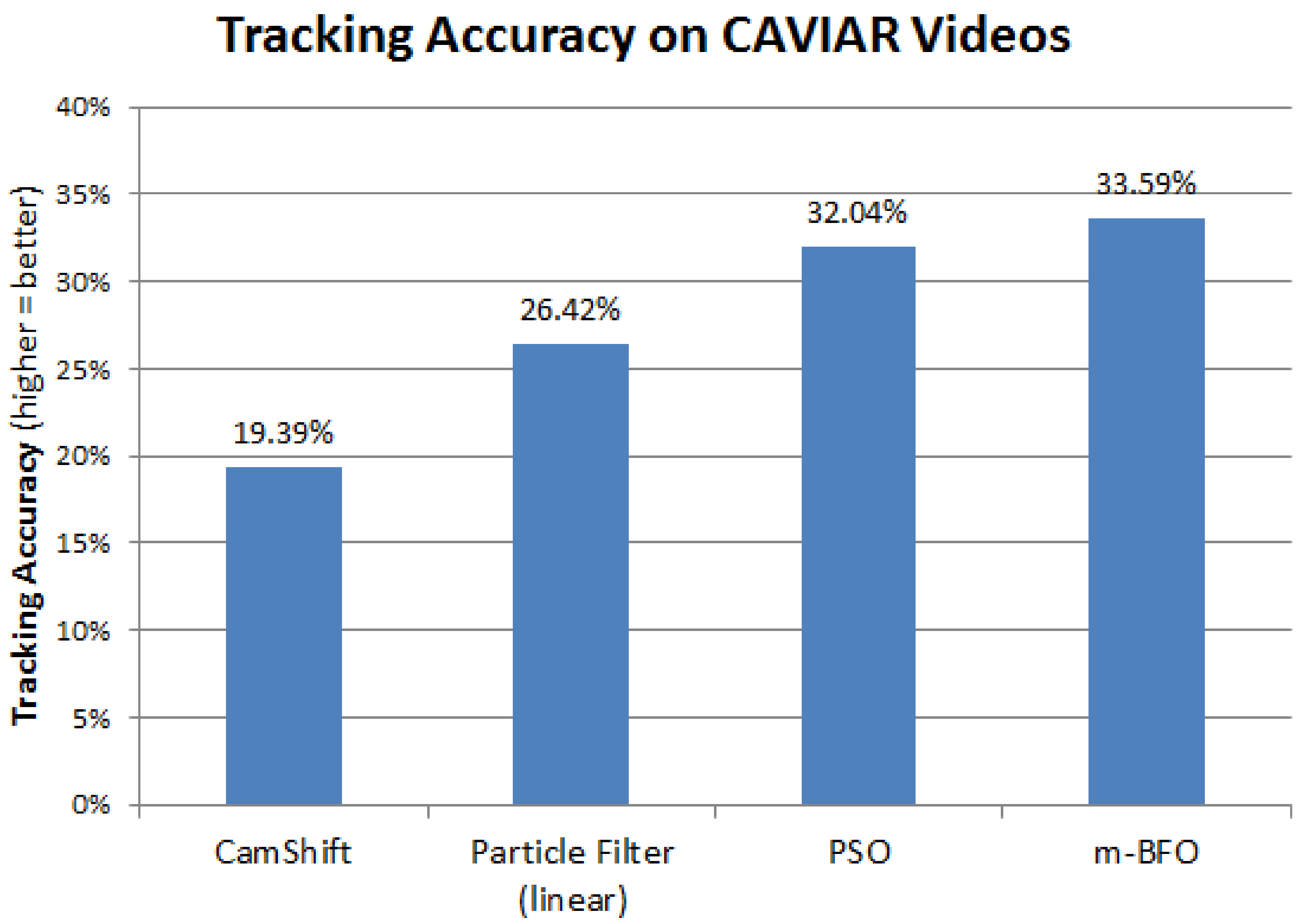
- i.e., tracking accuracy rate of “44%” means 26,000 of the 59,000 CAVIAR ROIs were correctly located with at least 50% groundtruth intersection
- **BFO:** 10 particles, 12 reproductions, 1 chemotactic step, 5 max swims per chemotaxis, 5px step size, 1 death/rebirth per reproduction, 90% dispersal rate
- **PSO:** 30 particles, 10 iterations

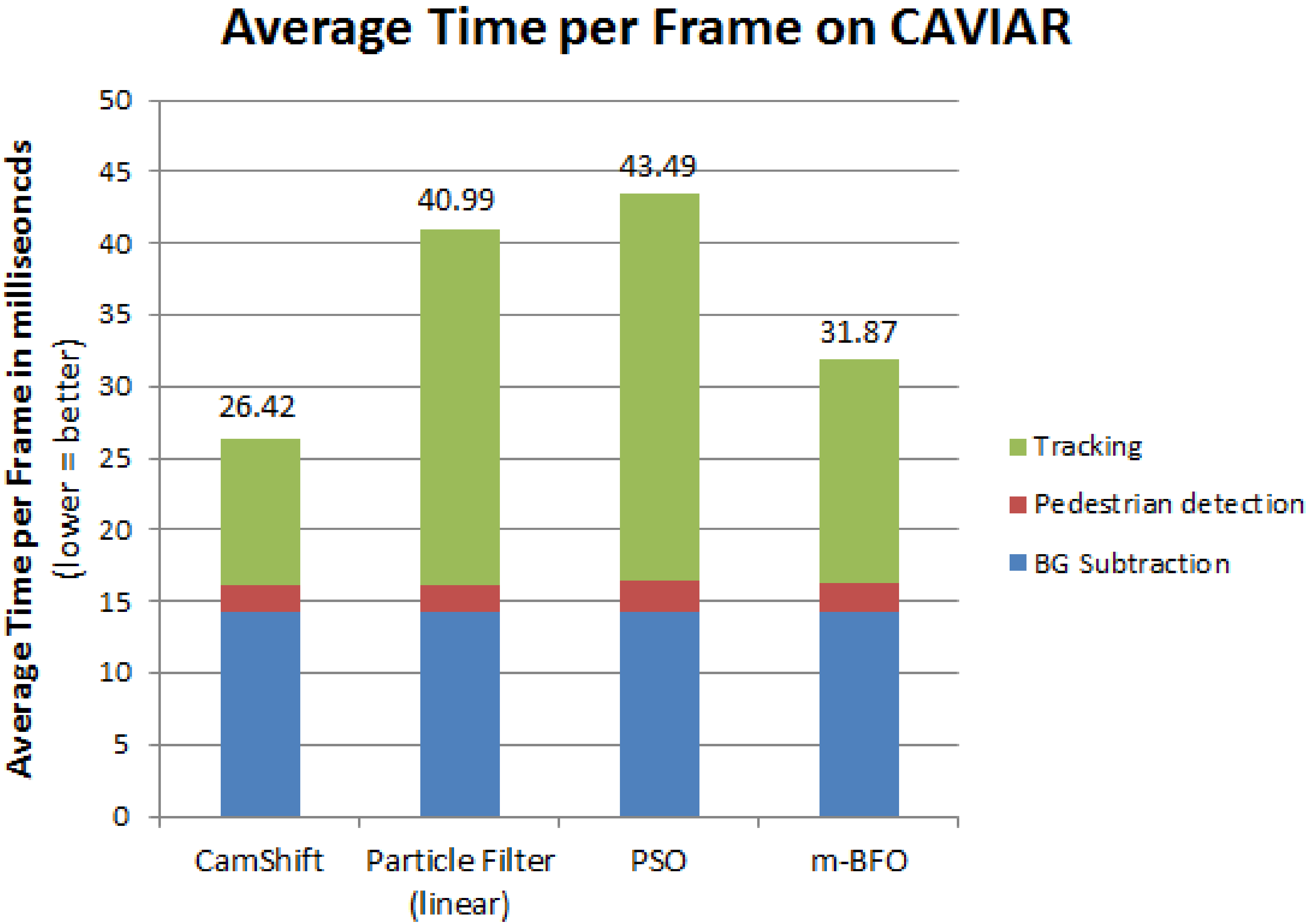
# Dataset

- 7 videos of the CAVIAR dataset considered to be the most difficult [Song, ECCV'10]




| Video | # Frames | # Pedestrians | # ROIs |
|---|---|---|---|
| OneShopOneWait1cor | 1,377 | 6 | 4,496 |
| OneStopMoveEnter1cor | 1,590 | 19 | 13,691 |
| ThreePastShop1cor | 1,650 | 8 | 9,642 |
| ThreePastShop2cor | 1,521 | 9 | 9,452 |
| TwoEnterShop1cor | 1,645 | 11 | 7,190 |
| TwoEnterShop2cor | 1,605 | 15 | 7,930 |
| TwoEnterShop3cor | 1,149 | 14 | 6,856 |
| **Total** | 10,537 | 82 | 59,257 |


Tracking Accuracy on CAVIAR Videos
Tracking Accuracy (higher = better)
40%
35%
30%
25%
20%
15%
10%
5%
0%
19.39%
26.42%
32.04%
33.59%
CamShift
Particle Filter (linear)
PSO
m-BFO


Average Time per Frame on CAVIAR
Average Time per Frame in milliseoncds
(lower = better)
50
45
40
35
30
25
20
15
10
5
0
26.42
40.99
43.49
31.87
CamShift
Particle Filter
(linear)
PSO
m-BFO
Tracking
Pedestrian detection
BG Subtraction

# Conclusions

- **Criteria: (B) Results are equal to / better than new scientific result**
- **Best because it helps facilitate real-time tracking systems with an algorithm which improves both accuracy and speed over traditional approaches.**