DeepFind: Sensor-driven Inference Acceleration for Continuous Deep Mobile Vision Applications

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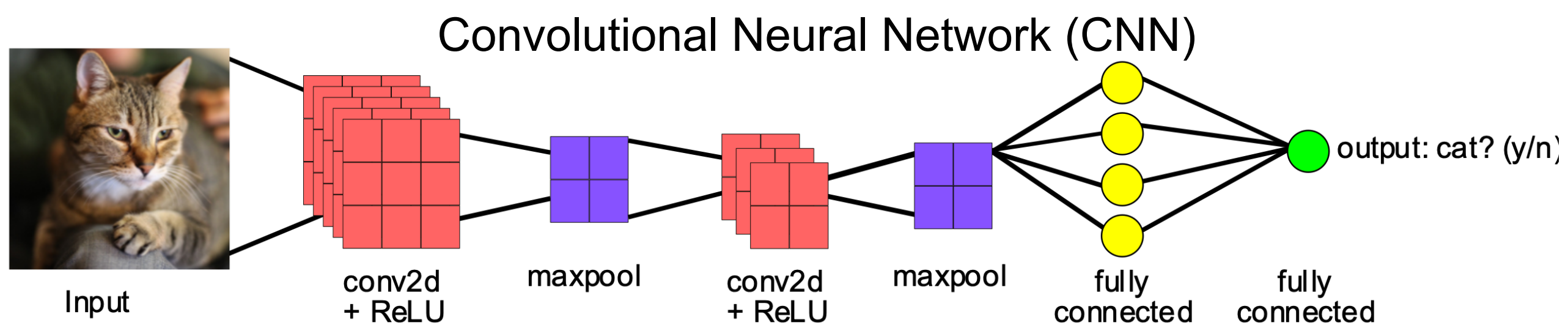
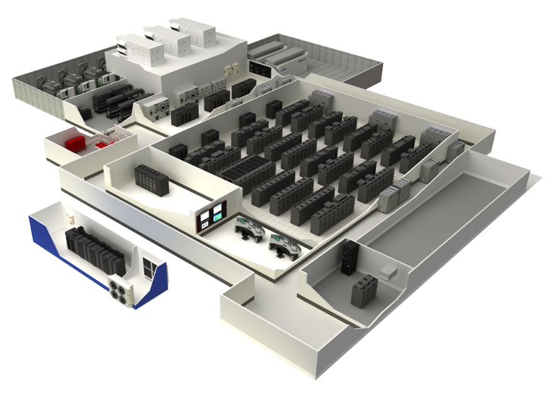
Problem and Goal

- Continuous vision enables smart environments

- Deep learning CNNs obtain human-scale accuracy



- Problem: CNN inference computationally expensive

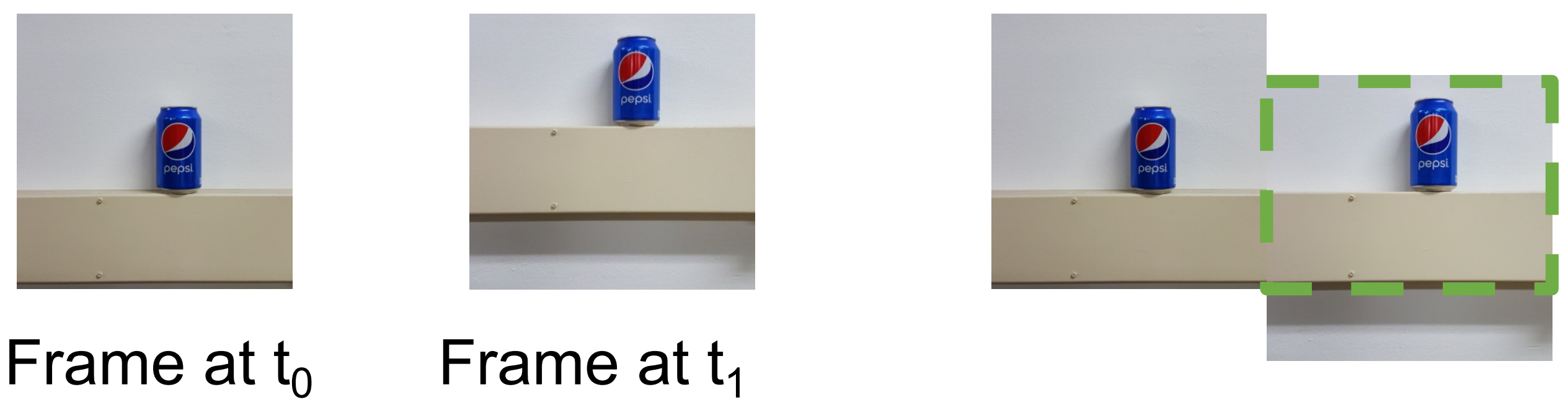


- Move data to cloud?
  - Privacy concerns
  - Network cost
- Move computation to edge?
  - Fewer resources than cloud (e.g., energy, computation)

Goal: enable deep learning vision to run continuously and efficiently on mobile and embedded devices.

Approach

- Consecutive frames enable caching opportunities

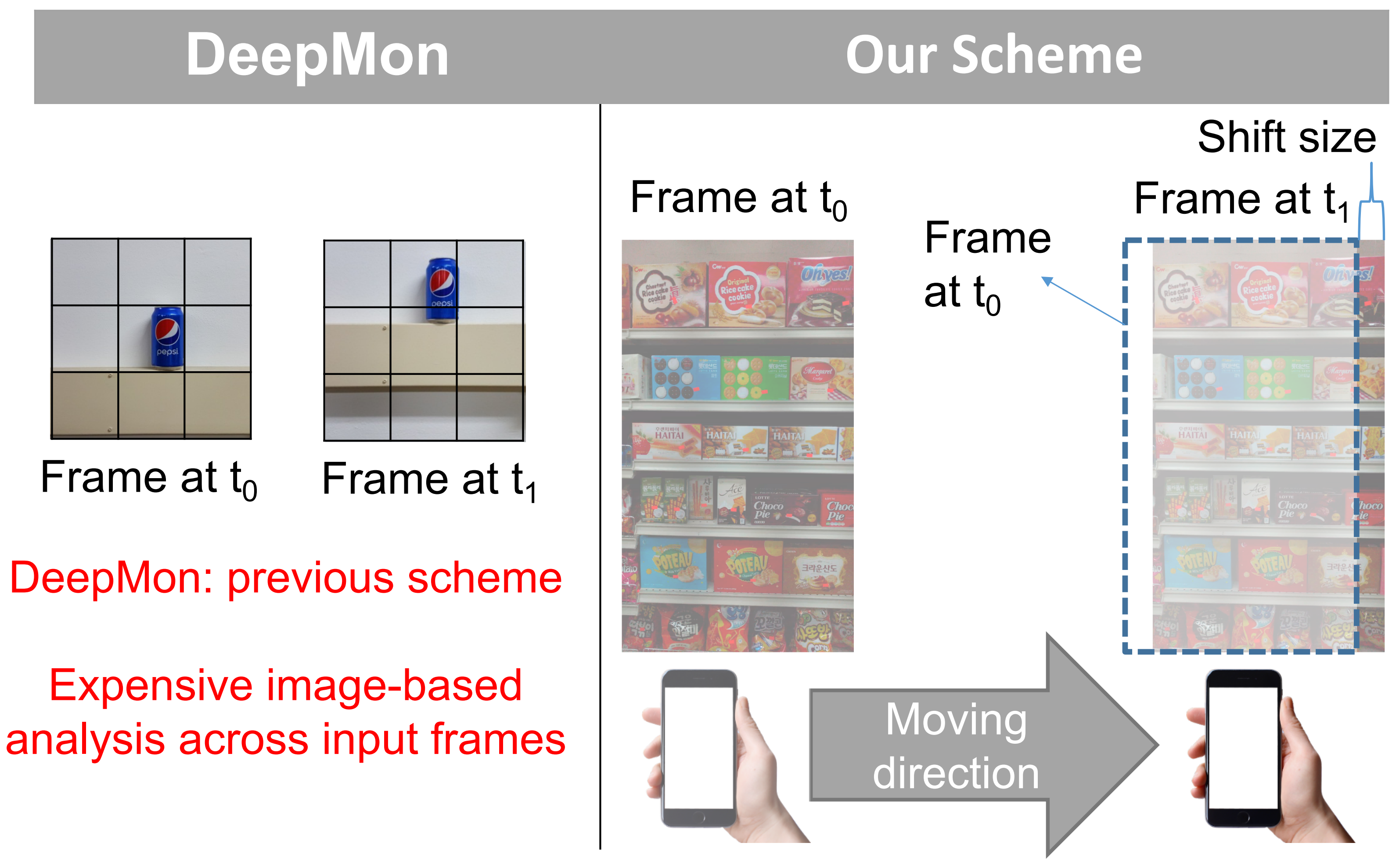


Frame at t_0 Frame at t_1

Frame at t_0 Frame at t_1

Green area can be reused

- How to determine cacheable regions?



DeepMon | Our Scheme

Frame at t_0 Frame at t_1

DeepMon: previous scheme

Expensive image-based analysis across input frames

Frame at t_0

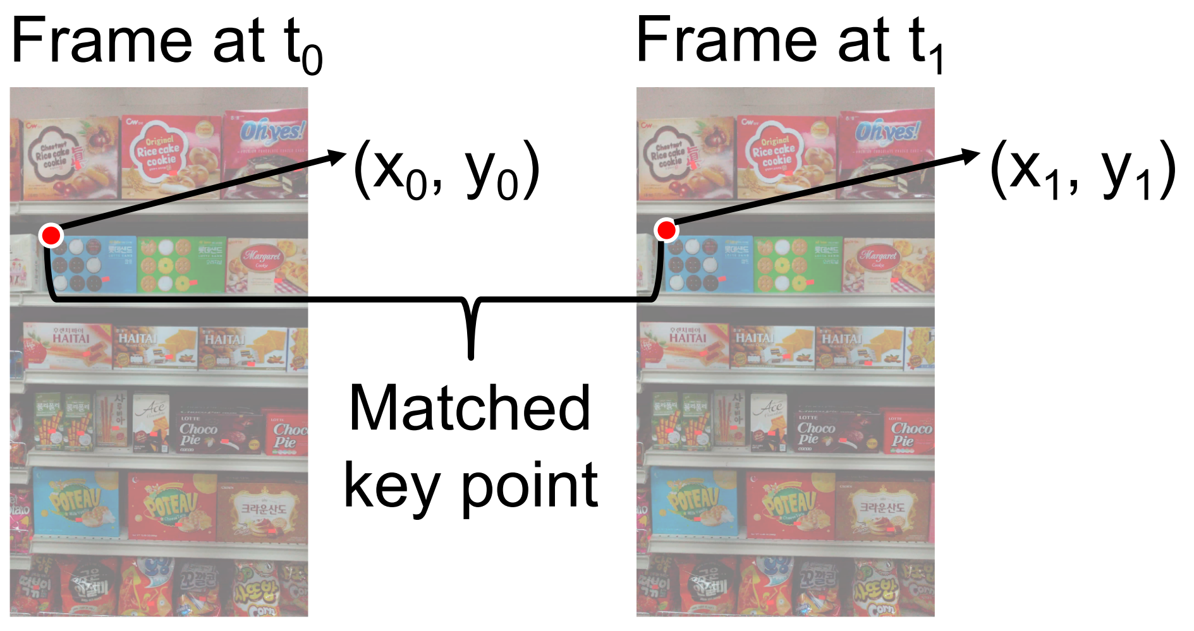
Frame at t_0

Shift size

Frame at t_1

Moving direction

- Converting spatial distance Δx to pixel distance Δp



Frame at t_0 Frame at t_1

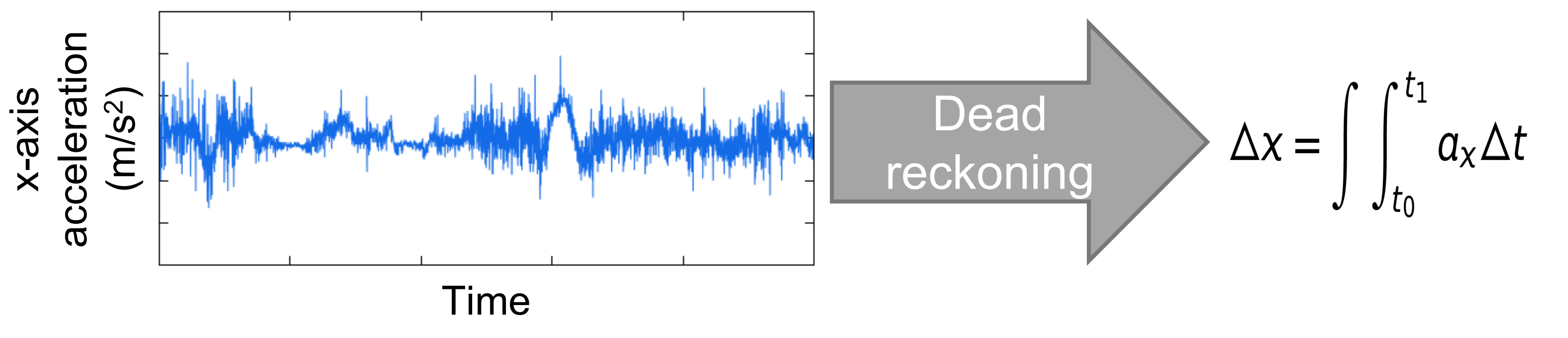
(x_0, y_0) (x_1, y_1)

Matched key point

Contributions

- Accelerate CNN on mobile and embedded devices
- A caching mechanism to reduce CNN inference time
  - Exploits spatial/temporal similarities in CNN inputs

  - Utilizes mobile sensors to determine similarities



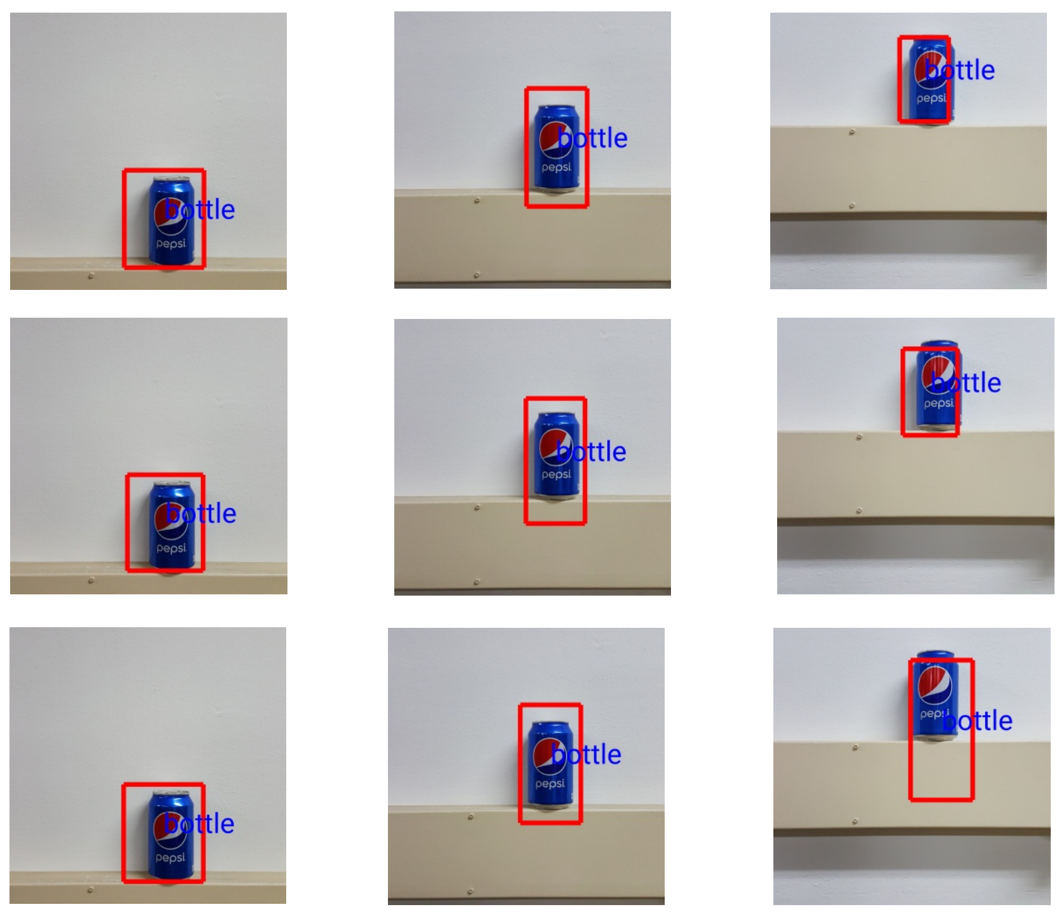
$$\Delta x = \int\int_{t_0}^{t_1} a_x \Delta t$$

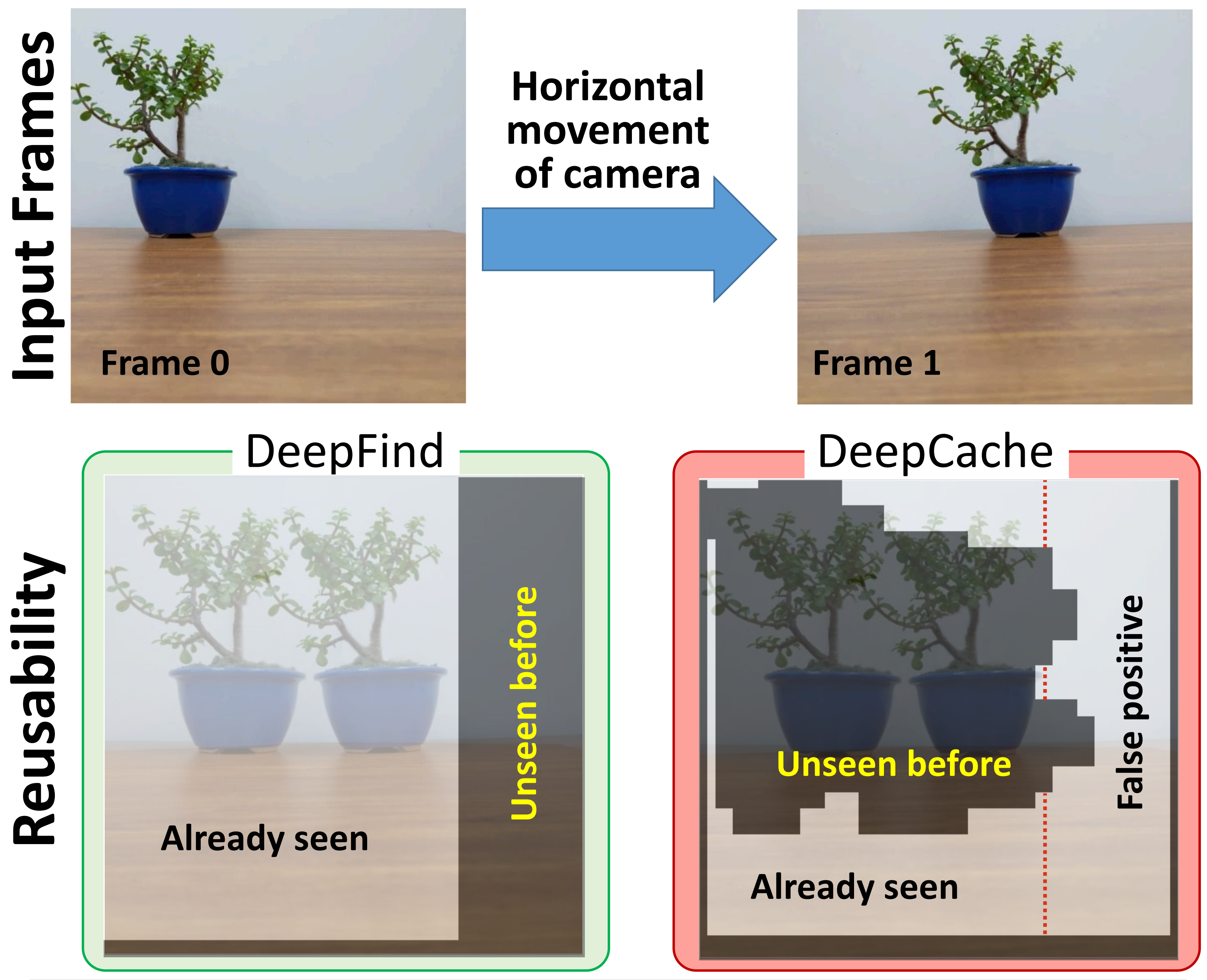
Accelerator reading while moving

Phone displacement

Evaluation

- Original Tiny-Yolo
- DeepFind
- DeepMon





Time to determine cached region (per frame)		
DeepFind	DeepMon	DeepCache
0.42 ms	6.0 – 18 ms	11 – 30 ms

Summary

- Continuous mobile vision important
  - Visual info provides context of users and environments
- Current deep learning algorithms are too expensive
  - Edge devices have less power, energy than cloud
- Our work makes efficient continuous vision on mobile and embedded devices a reality
  - Allows personalized intelligence to become truly pervasive