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GLAMAR: Geo-Location Assisted Mobile Augmented Reality for Industrial Automation

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Mobile Augmented Reality (MAR) for Industrial Automation

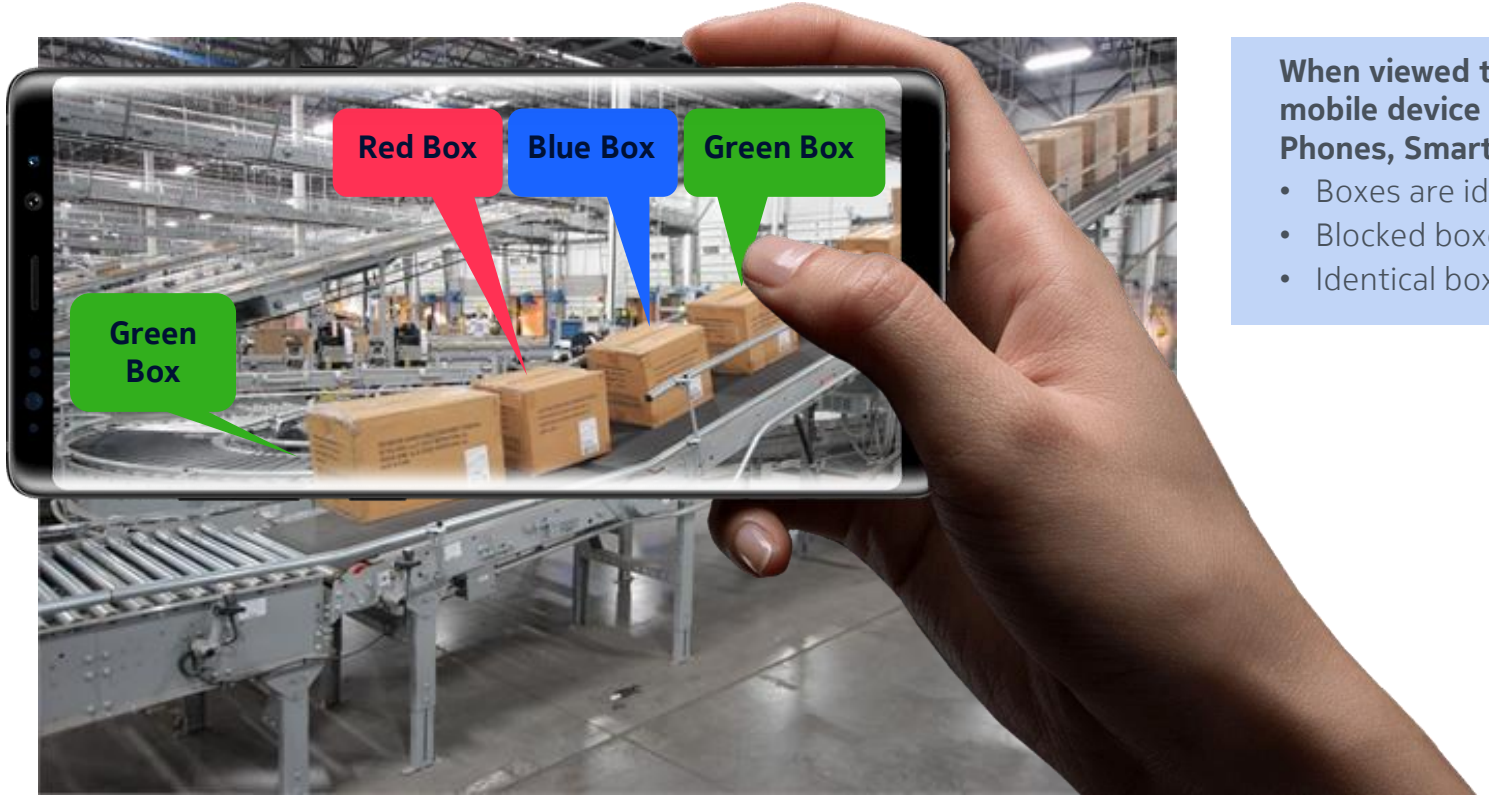
- Augmented Reality (AR) is going to play a significant role in transforming and automating Future Industry.
- Consumer mobile devices (e.g., Smart Phone, Smart Glasses) will bring in widespread adoption of AR in industry.
- Mobile AR (MAR) has some practical limitations due to the constrained capabilities of the devices (processing, battery).
- We propose a framework for efficient support of MAR on smart devices by leveraging the enhanced facilities installed in Future Industry.

Role of Mobile Augmented Reality (MAR) for Industrial Automation

Identification and control of objects in a digital warehouse is challenging when they are

- Moving,
- View is blocked, or
- Identical looking

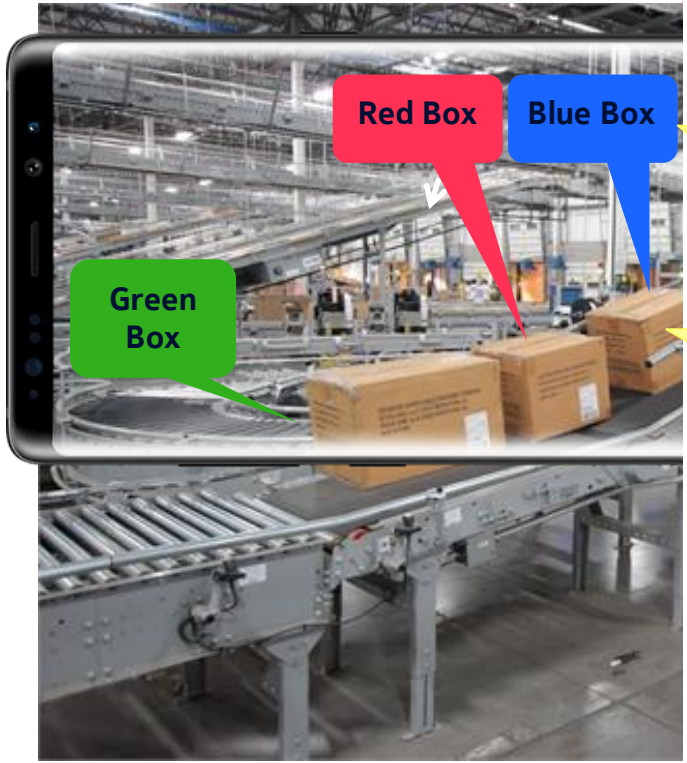
Role of Mobile Augmented Reality (MAR) for Industrial Automation

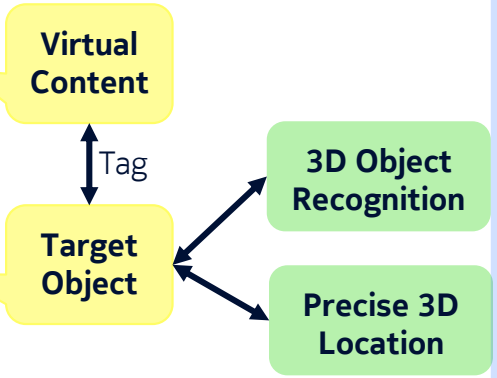


When viewed through AR enabled mobile device (e.g., Smart Phones, Smart Glasses)

- Boxes are identified/tagged,
- Blocked boxes are tagged
- Identical boxes differentiated

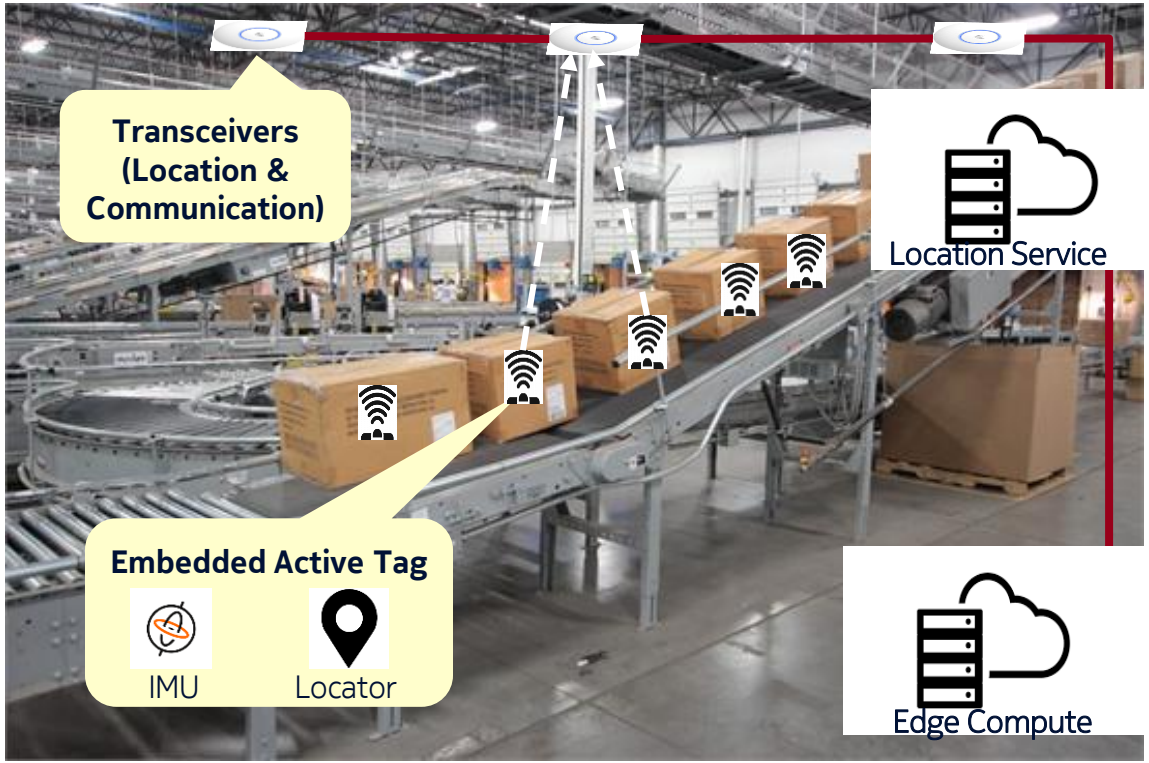
Challenges in Supporting MAR for Industrial Automation





- State of the art computer vision-based techniques are impractical for mobile devices.
- In addition, vision-based techniques hindered by
  - Distance to object
  - Object occlusion
  - Similar looking objects
- 3D point cloud based solutions are expensive for MAR.
- Recently proposed MAR-based solutions have limited application.

Our Approach: Geo-Location Assisted MAR (GLAMAR)



Leverage the future industry infrastructure to support MAR-based application efficiently on smart devices

- Location Service,
- Smart sensor
- Low latency communication,
- Edge compute

Our Approach: Geo-Location Assisted MAR (GLAMAR)

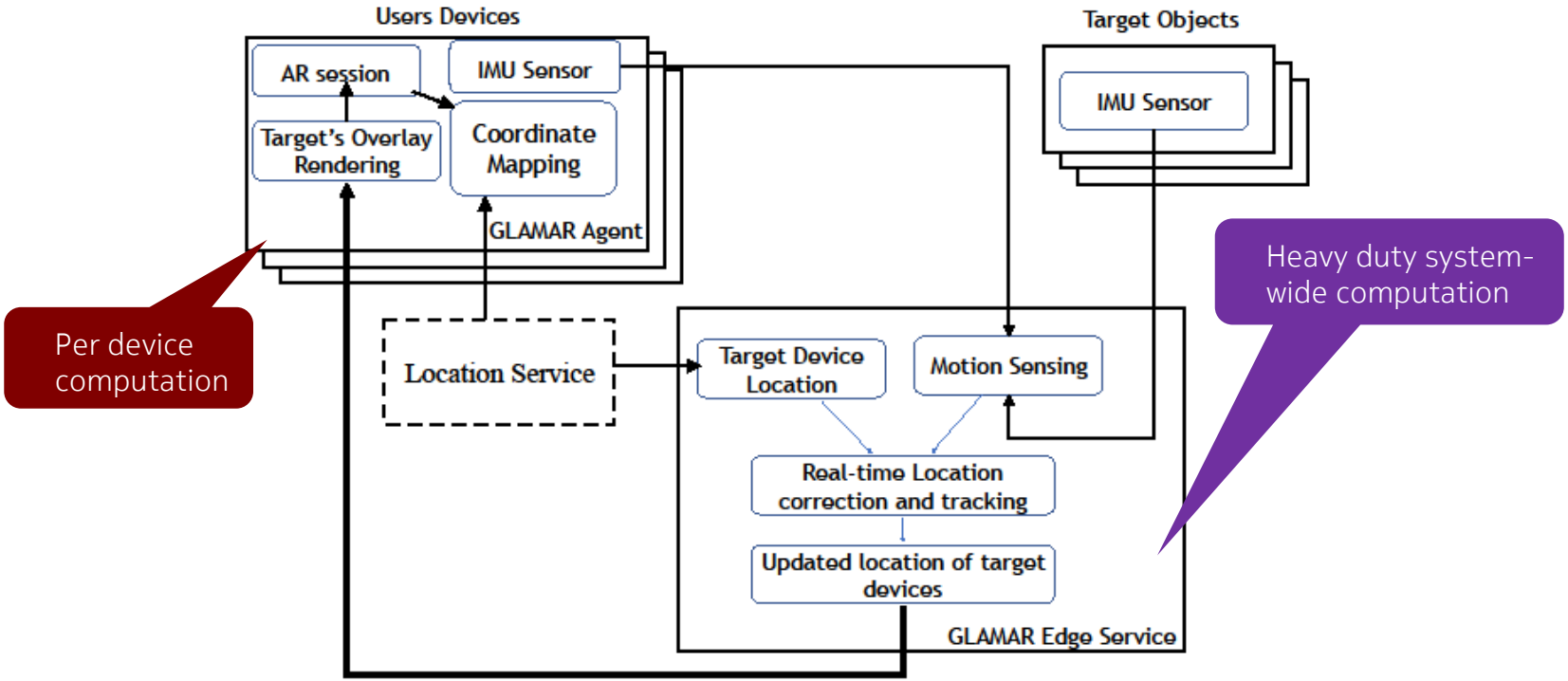
External location instead of target object location tracking.

- Handles both stationary and mobile target objects.
- Does not suffer from occlusion.
- No distance constraint between user and objects.
- But accuracy can fluctuate.

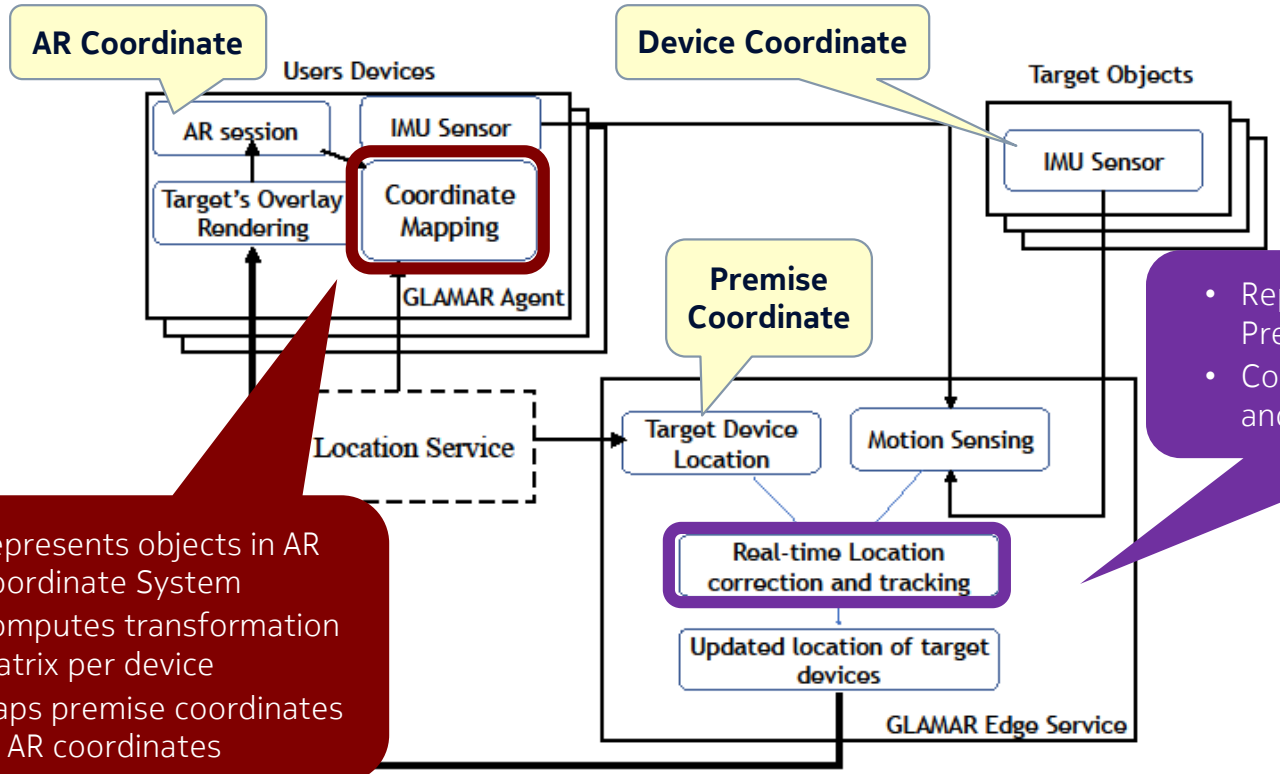
Precise location computation of target objects offloaded to edge.

- IMU data improves accuracy.

GLAMAR System Overview



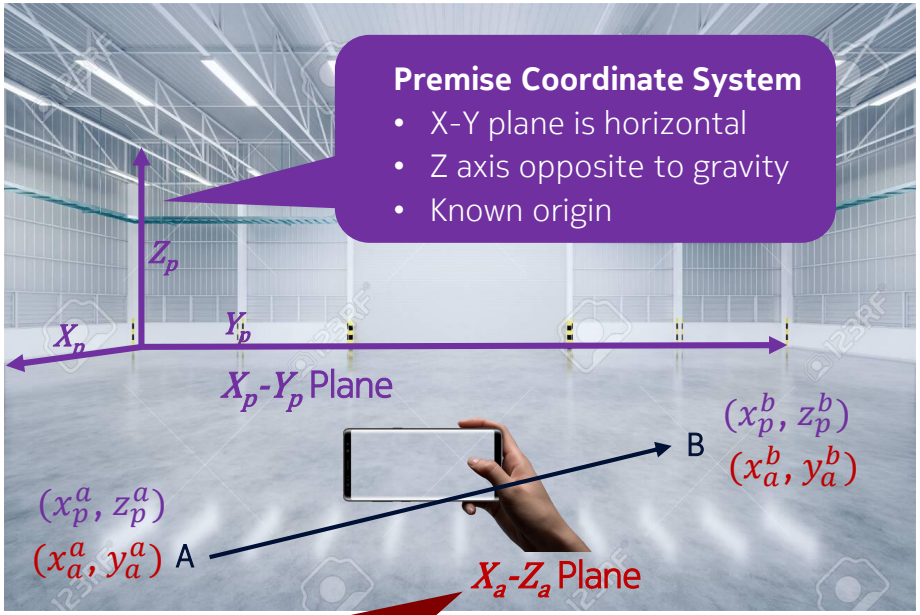
GLAMAR System Overview: Mapping Coordinate Systems



- Represents objects in AR Coordinate System
- Computes transformation matrix per device
- Maps premise coordinates to AR coordinates

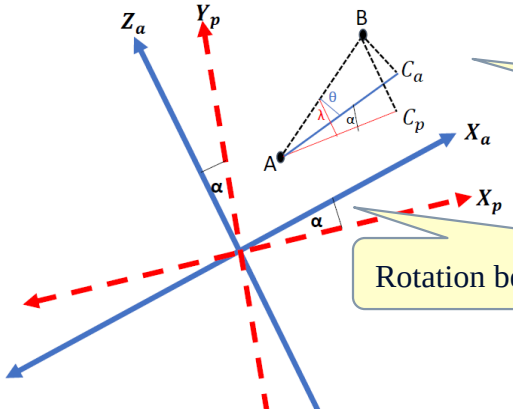
- Represents target objects in Premise Coordinate System
- Conducts location correction and tracking of target objects

Mapping Coordinate Systems: Premise Coordinates to AR Coordinates



AR Coordinate System
- X-Z plane is horizontal
- Y axis opposite to gravity
- Non-trivial to know origin

Premise Coord x (Rotation & Translation) = AR Coord



Z_p and Y_a axes are aligned

Rotation between X_p-Y_p and X_a-Z_a planes

$$\alpha = \arctan\left(\frac{y_p^b - y_p^a}{x_p^b - x_p^a}\right) - \arctan\left(\frac{z_a^b - z_a^a}{x_a^b - x_a^a}\right)$$

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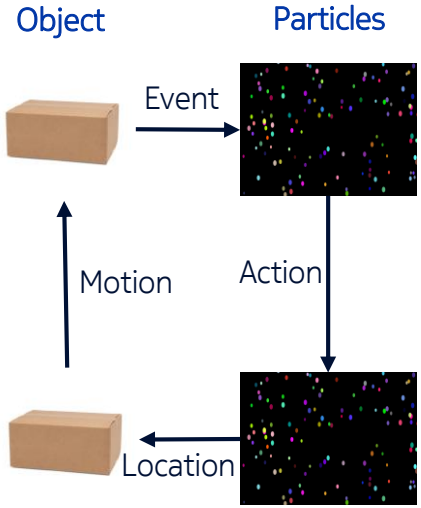
Real-time Location Correction and Tracking: Regenerative Particle Filter

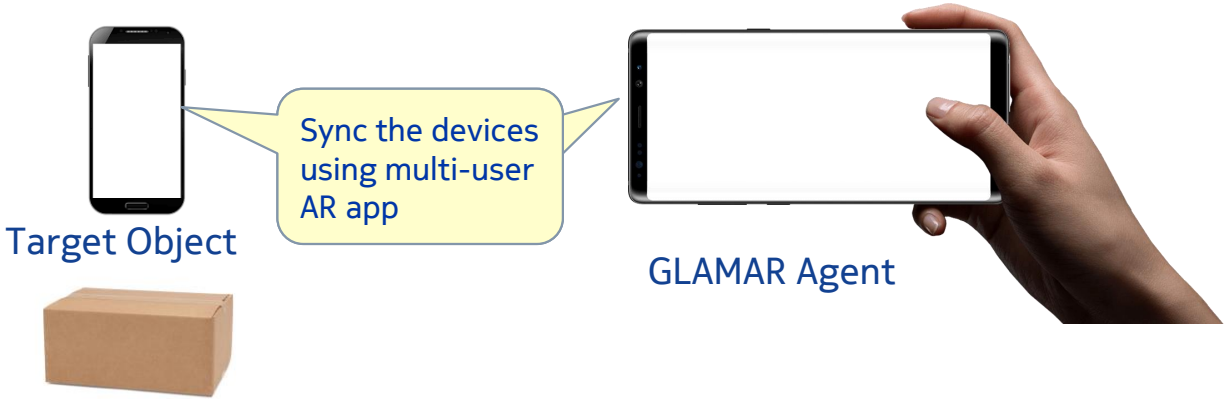
Event	Property	Action
Acceleration Update	Noisy, non-zero when stationary	• Update location of *n* particles based on the noise model of the acceleration • Update acceleration to new value
Location Update	Noisy, prone to interference	• Update location of *n* particles based on the noise model of the acceleration • **Resample**: Generate new maximum likely *n* particles from old particles based on new location value
Motion Update (stationary)	Stable and high confidence	• Calculate expected location of the object • **Regeneration**: Generate *n* stationary particles around that location

Freezing particles does not work

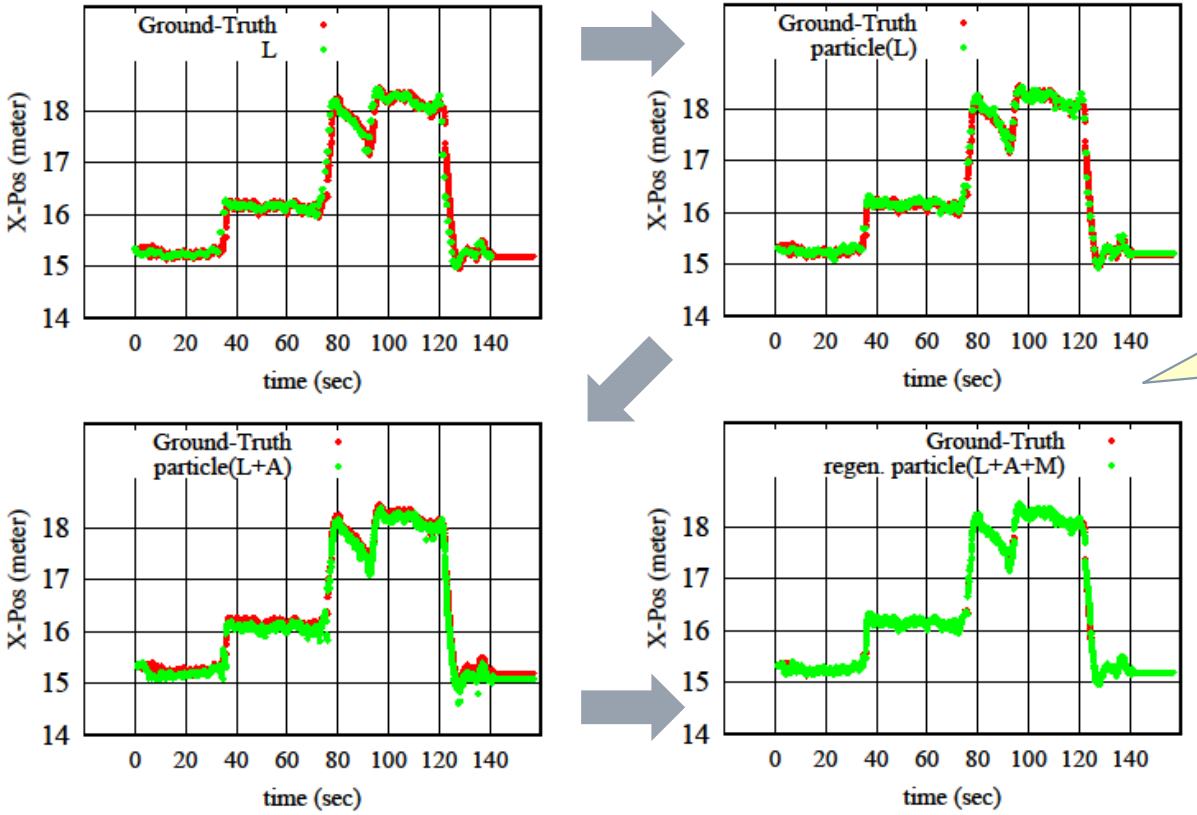


Evaluation

- GLAMAR Framework is useful, if
  - For Accuracy:: GLAMAR ≅ Vision based
  - For Energy Efficiency:: GLAMAR ≫ Vision based
- **Accuracy**: Displacement of augmented object w.r.t “ground truth” in 3D coordinates



Effect of Regenerative Particle Filter



Accuracy improves by our regenerative particle filter in tracking a moving target object as more types of events are used

Summary of Contributions

MAR-based industrial applications can be made practical and easily adoptable

- Application demands on smart phone resources are kept very low by leveraging the new industry 4.0 technologies like object localization, edge computation, low latency networking.

Develop an edge computation friendly framework called GLAMAR

- Determine and distribute location of target objects in real-time to all MAR-based applications.
- Ensure accurate image augmentation even in the presence of errors and fluctuations
  - Edge-hosted, computation heavy, regenerative particle filter-based location estimation
  - On-device, lightweight, coordinate transformation matrix computation

Implement MAR-based applications using commercial SDKs

- Demonstrate significant advantages provided by GLAMAR compared to legacy vision-based techniques.
- Develop a novel ground truth measurement mechanism to track target objects in real world units (e.g., meter) instead of pixels, which most of the literature works in MAR use.

Thank you

For questions and comments:: sarit.mukherjee@nokia-bell-labs.com