

BACKGROUND

RGB cameras lose track the moment a person is occluded by walls or obstacles. mmWave radar (60-64 GHz) can see through non-metallic materials but lacks the resolution for skeleton tracking. FALCON fuses an Intel RealSense camera with a TI IWR6843 mmWave radar to maintain continuous identity and 3D position through full occlusion

MOTIVATION AND OBJECTIVES

- Maintain continuous person tracking during complete visual occlusion
- Execute seamless radar ↔ camera handoff in ≤ 2 frames with zero identity loss
- Run in real-time at ≥ 20FPS on embedded NVIDIA Orin Nano
- Support tracking of 2+ people in a shared environment
- Deliver an end-to-end calibrated, deployable fusion system

THE TECHNOLOGY

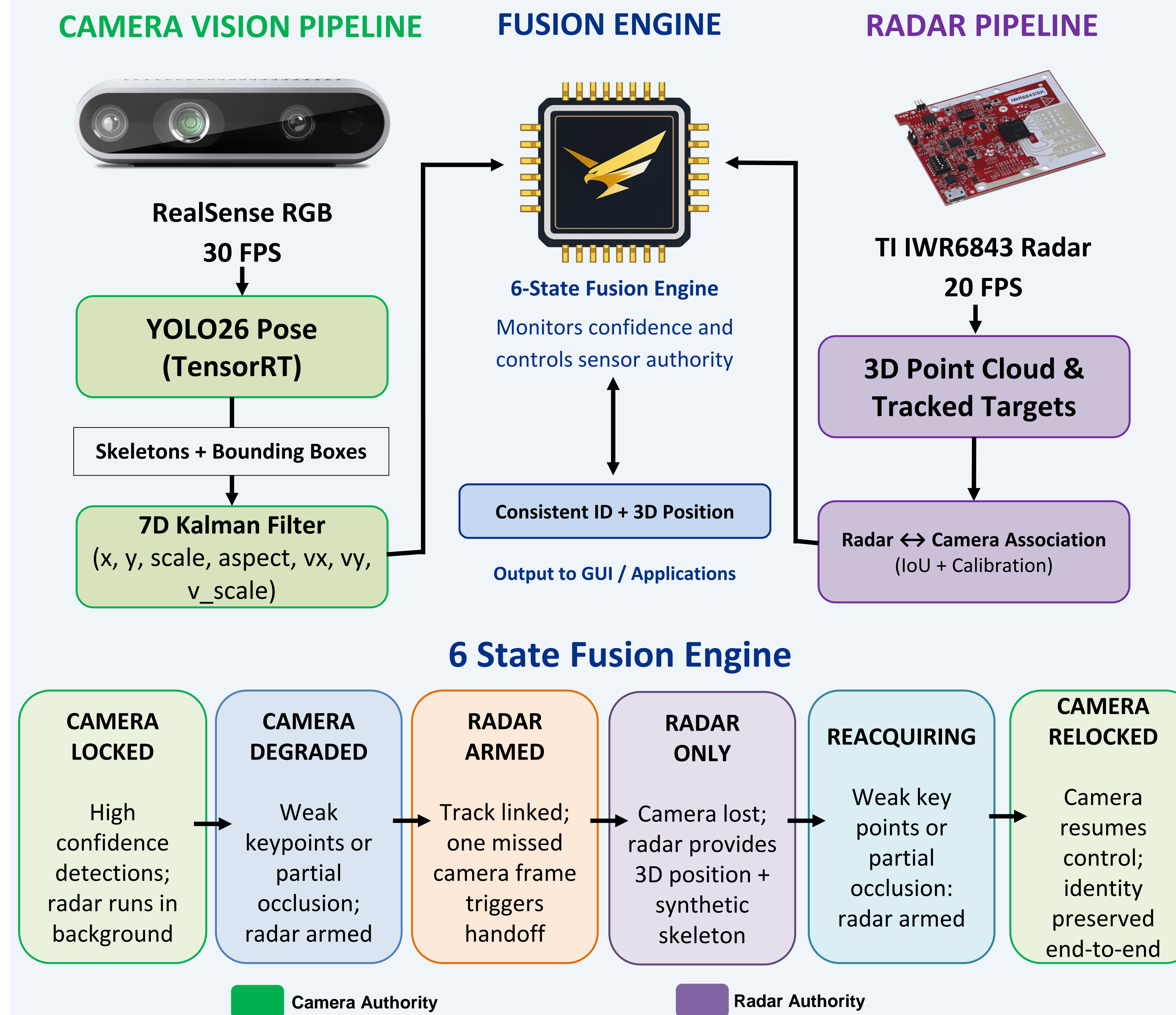
HARDWARE

- Intel RealSense Depth Camera**
RGB + depth streaming at 30 FPS
- TI IWR6843ISK mmWave Radar**
60-64 GHz, 3D people-tracking
- TI MMWAVEICBOOST Carrier Board**
USB/UART interface for radar configuration and data streaming
- NVIDIA Orin Nano**
CUDA / TensorRT on-device inference

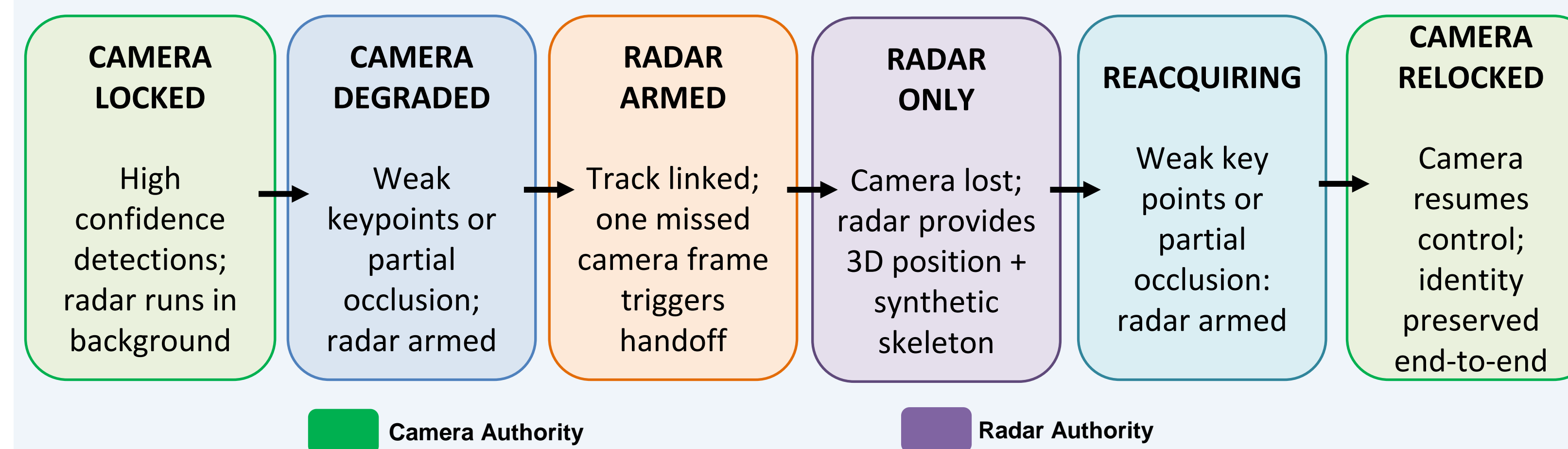
SOFTWARE

- YOLO26 Pose (TensorRT)**
Real-time human skeleton detection at ~30 FPS on embedded GPU
- 7D Kalman Filter**
Predicts position, velocity, and scale to maintain stable tracking during dropouts
- Radar-Camera Association**
Projects radar detections into image space using calibrated pinhole model (IoU matching)
- Extrinsic Calibration System**
Aligns radar and camera coordinate frames using reprojection error minimization
- Real-Time Visualization GUI**
Displays bounding boxes, skeletons, and radar overlays for debugging and demo

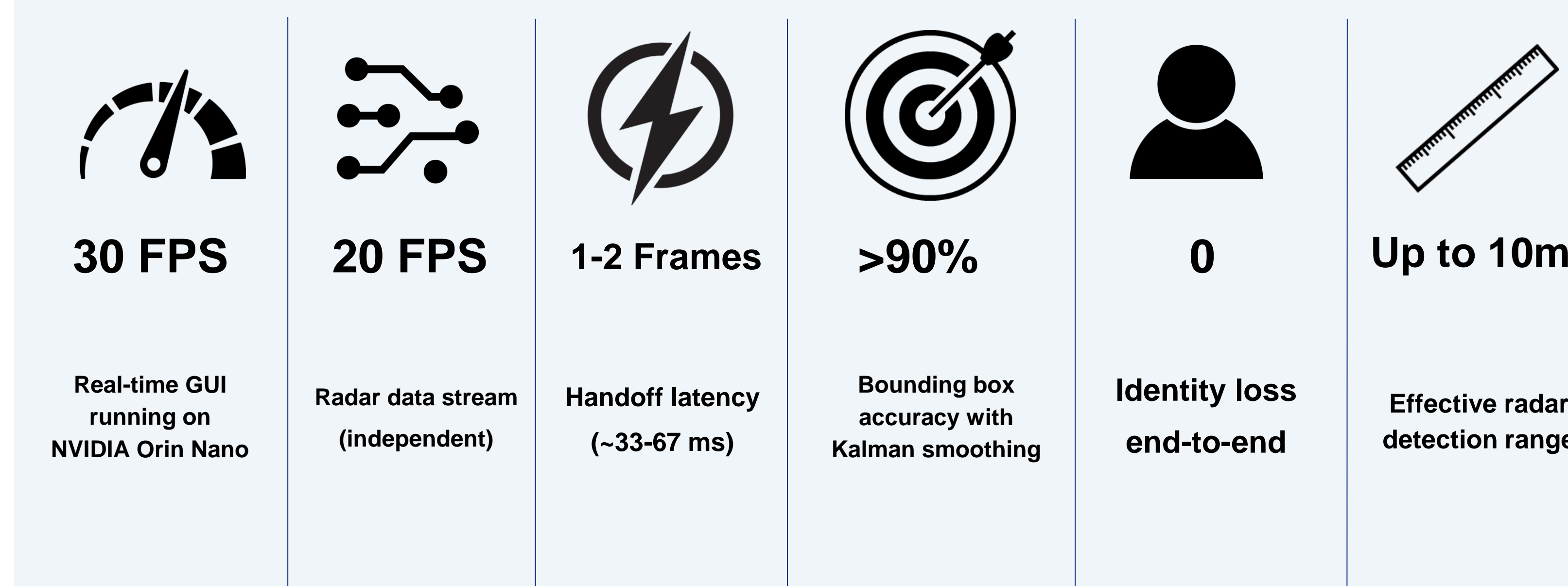
METHODOLOGY AND SYSTEM DESIGN



6 State Fusion Engine

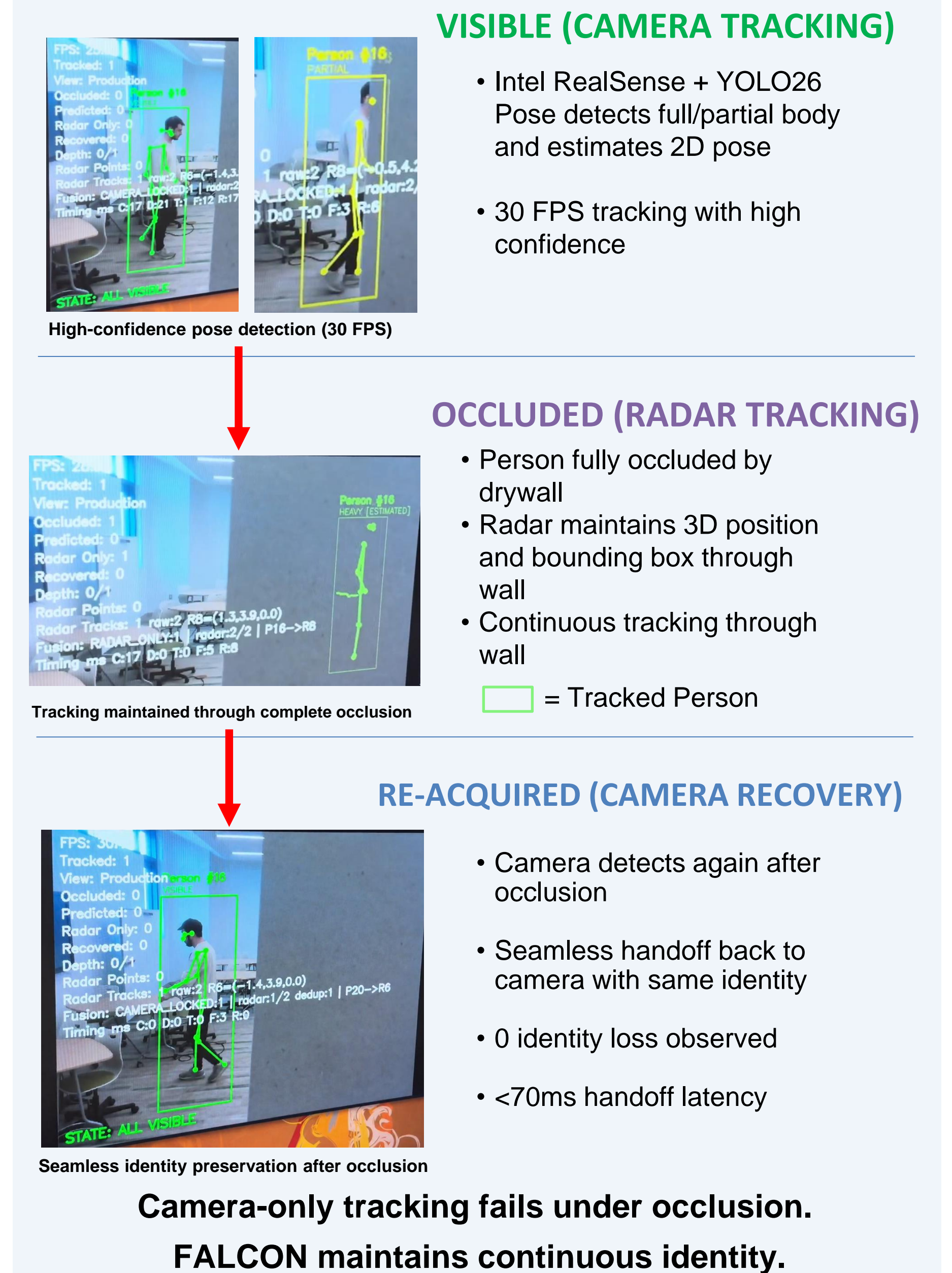


PERFORMANCE HIGHLIGHTS



CONTINUOUS HUMAN TRACKING. EVEN THROUGH WALLS.

RESULTS & VALIDATION



VISIBLE (CAMERA TRACKING)

- Intel RealSense + YOLO26 Pose detects full/partial body and estimates 2D pose
- 30 FPS tracking with high confidence

OCCLUDED (RADAR TRACKING)

- Person fully occluded by drywall
- Radar maintains 3D position and bounding box through wall
- Continuous tracking through wall
- Legend: = Tracked Person

RE-ACQUIRED (CAMERA RECOVERY)

- Camera detects again after occlusion
- Seamless handoff back to camera with same identity
- 0 identity loss observed
- <70ms handoff latency

Camera-only tracking fails under occlusion. FALCON maintains continuous identity.

CONCLUSION

Conclusion

FALCON achieves robust, real-time human tracking through complete occlusion by intelligently fusing radar and vision. Our 6-state fusion engine enables near-instant handoffs with zero identity loss, outperforming camera-only baselines

Future Work

- 3D pose recovery during radar-only phases via skeleton deformation
- Hardened multi-person ID management for crowded scenes (3+)
- Outdoor and non-line-of-sight environment deployment
- Automatic spatial alignment to reduce calibration complexity

REFERENCES

- Texas Instruments. IWR6843 mmWave People Tracking Ref. Design. 2023.
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- Welch, G. & Bishop, G. An Introduction to the Kalman Filter. UNC, 2006.
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