Kalman Filter-Based Suspicious Object Tracking for Border Security and Surveillance System using Fixed Automotive Radar

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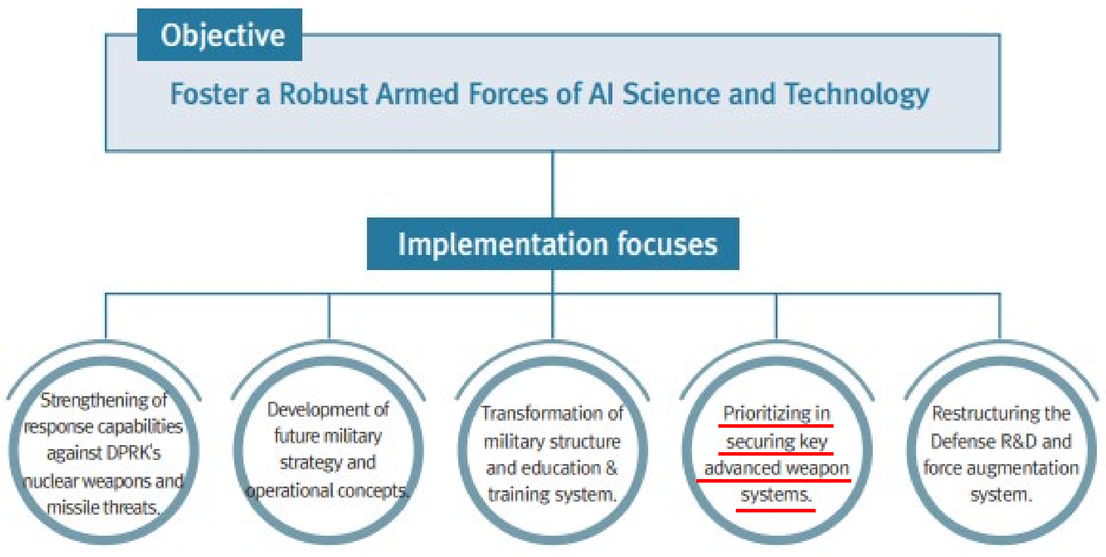
1. Background

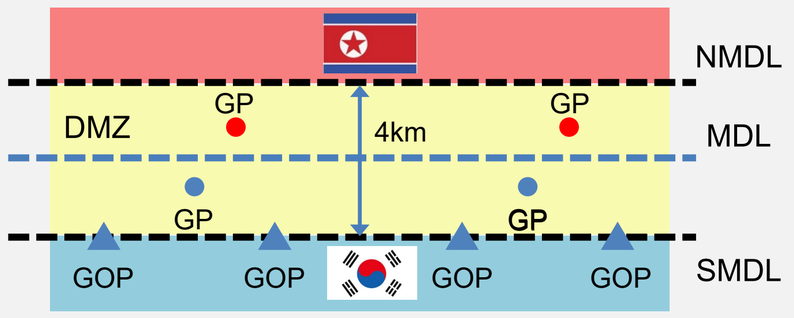
Defense Innovation 4.0



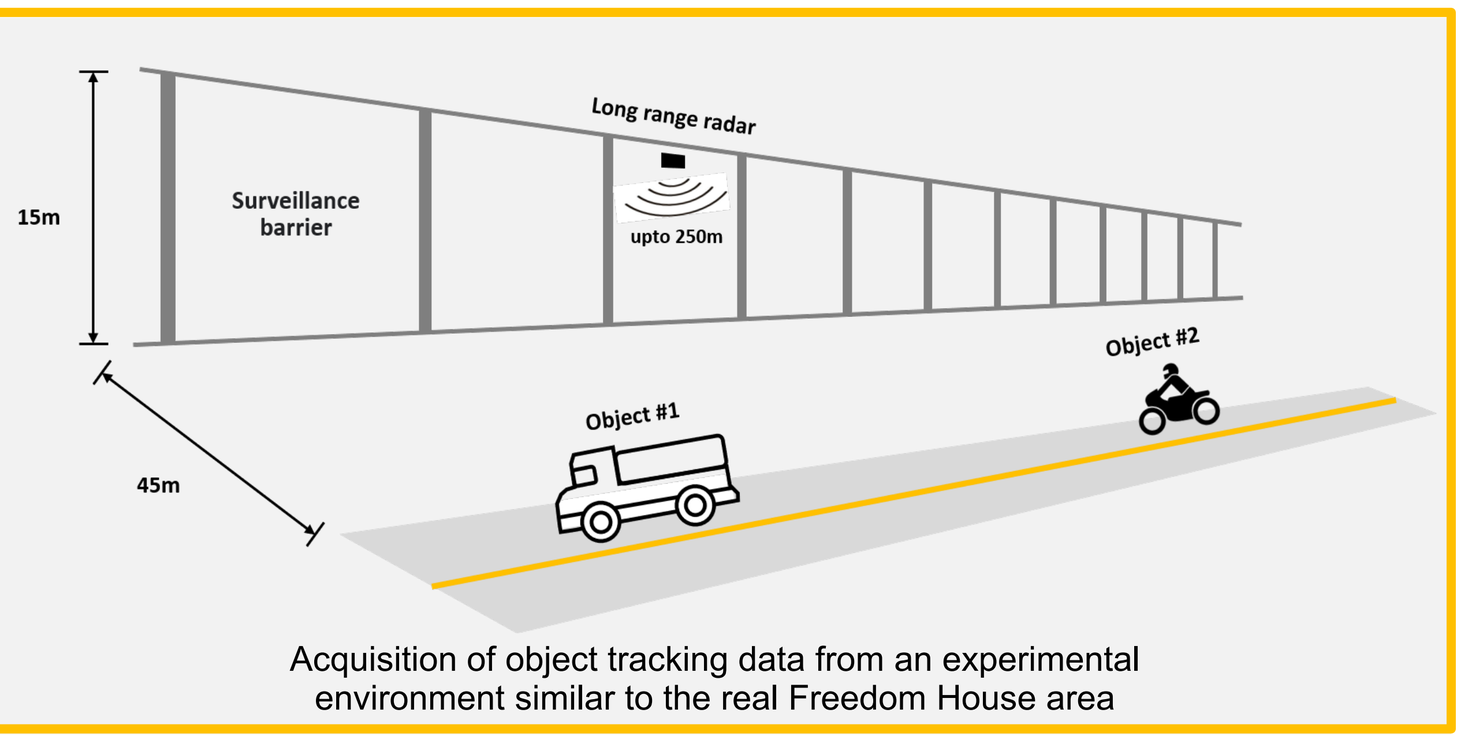
- Achieving deterrence against North Korea by vastlystrengthening response capabilities against their nuclear weapons andmissile threats
- Fulfilling operational execution capabilities with competitive advantage based on cutting-edge science & technology, e.g. AI, unmanned, and robot, etc.

Unmanned Border system

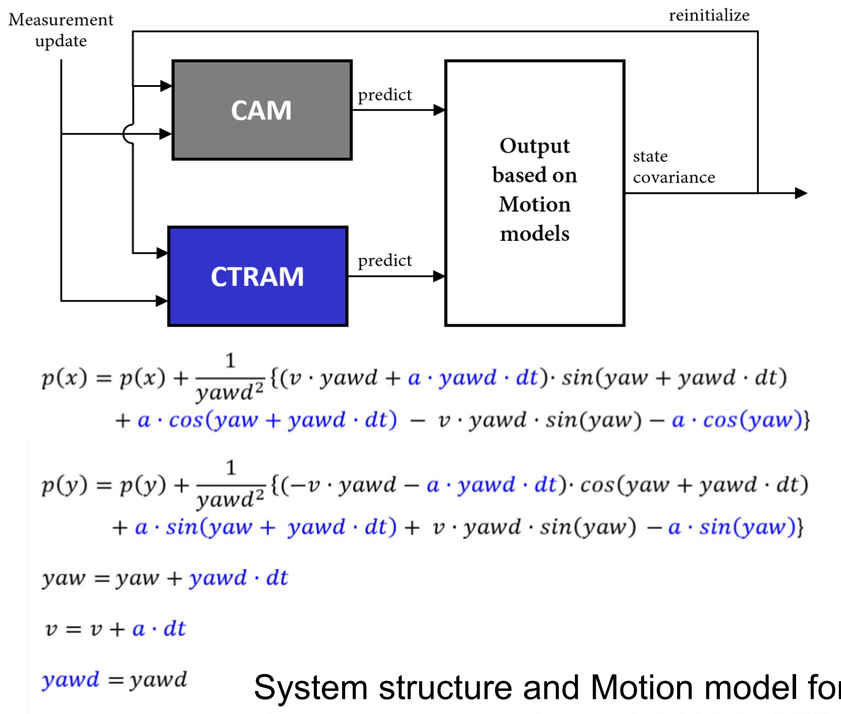
- ROK MDL line : 250km
  * DMZ : Demilitarized Zone
- GP(Guard Post) : 00
- GOP (General Outpost) : 000
- Typical terrain
  - Mountain, flat land with roads



2. Experiment



Acquisition of object tracking data from an experimental environment similar to the real Freedom House area



$$p(x) = p(x) + \frac{1}{yawd^2}\{(v \cdot yawd + a \cdot yawd \cdot dt) \cdot sin(yaw + yawd \cdot dt) + a \cdot cos(yaw + yawd \cdot dt) - v \cdot yawd \cdot sin(yaw) - a \cdot cos(yaw)\}$$

$$p(y) = p(y) + \frac{1}{yawd^2}\{(-v \cdot yawd - a \cdot yawd \cdot dt) \cdot cos(yaw + yawd \cdot dt) + a \cdot sin(yaw + yawd \cdot dt) + v \cdot yawd \cdot sin(yaw) - a \cdot sin(yaw)\}$$

$$yaw = yaw + yawd \cdot dt$$

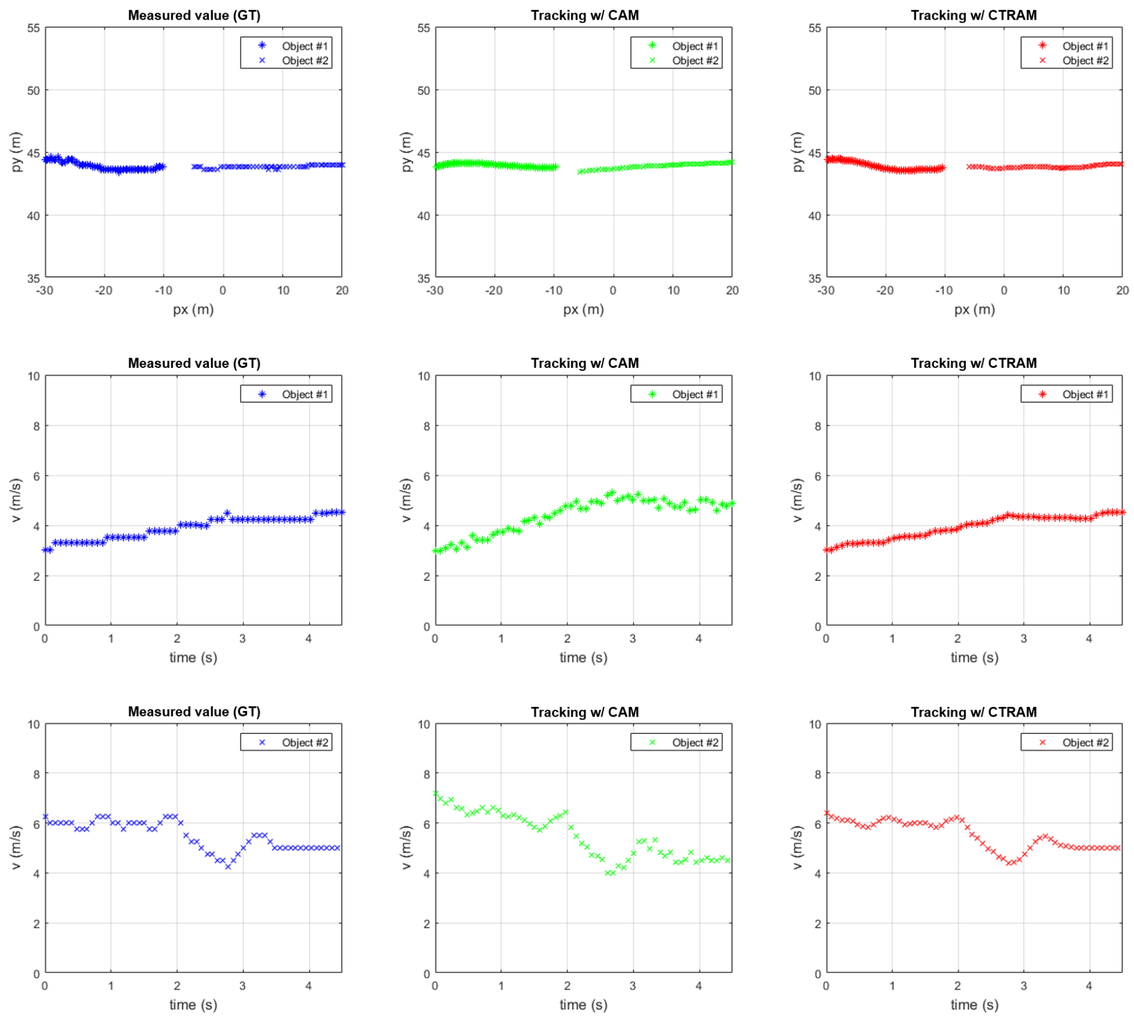
$$v = v + a \cdot dt$$

$$yawd = yawd$$

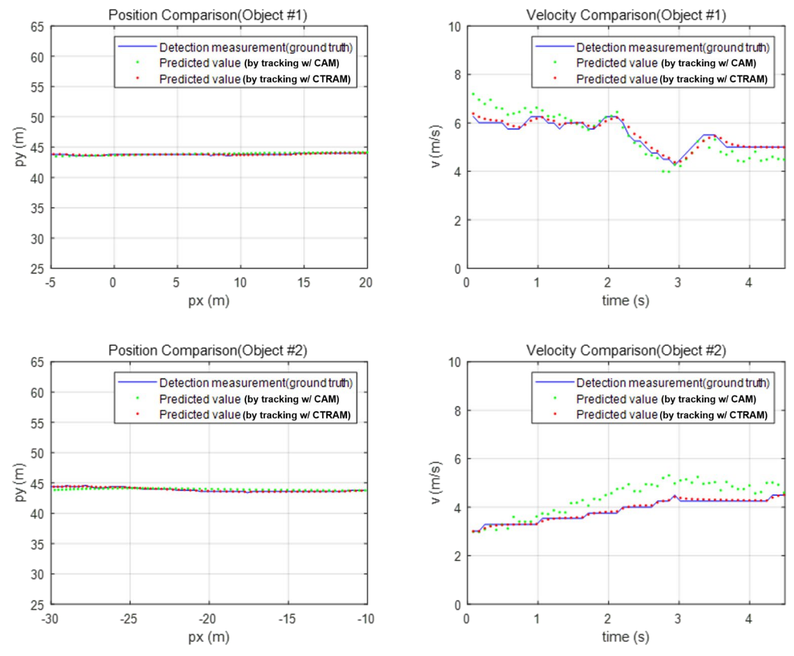
$$a = a$$

System structure and Motion model for performance comparison of CAM & CTRAM

3. Result



Comparison of tracking performance with CAM and CTRAM (position and velocity)



Tracking performance evaluation (position& velocity)

TABLE I: Standard deviation of radar measurement noise for CAM and CTRAM. The units of parameters are m, m/s, m/s^2, rad, and rad/s.

Parameters	CAM				CTRAM				
	px, py	vel	yaw	$yaw\,rate$	px, py	vel	acc	yaw	$yaw\,rate$
Value	0.1	0.1	0.1	0.5	0.1	0.1	0.01	0.1	0.5

TABLE II: Root mean square error (RMSE) w.r.t. measured data (CAM and CTRAM) for objects 1 and 2

RMSE	object 1		object 2	
	CAM	CTRAM	CAM	CTRAM
Position	0.1660	0.0695	0.3009	0.0902
Velocity	0.7338	0.1264	0.8070	0.0584

TABLE III: Processing time comparison (s)

	Average time	Std. dev. time
Tracking w/ CAM	0.00118015	0.00031656
Tracking w/ CTRAM	**0.00222676**	**0.00082623**

4. Conclusion

The possibility that automotive radar can be applied in boundary monitoring systems was confirmed

South Korean military is trying to implement a science and technology force by promoting "Defense Innovation 4.0`," and a high-efficiency and highly effective detection system can be developed through the implementation of a radar-based scientific security system using Kalman filters