Temasek Defence Systems Institute

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A BROWNIAN BRIDGE MOVEMENT MODEL TO TRACK MOBILE TARGETS

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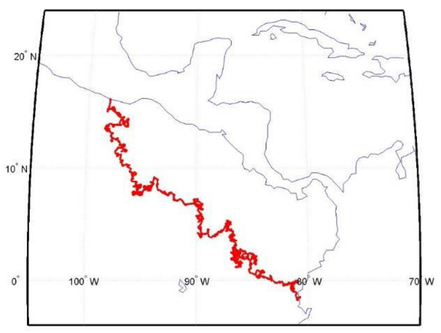
Objective:

- To use a mathematical model to predict the movement of a target
- Goal is to allow unmanned sensors to move autonomously while maximizing Probability of Detection (Pd)

Brownian Bridge Movement Model

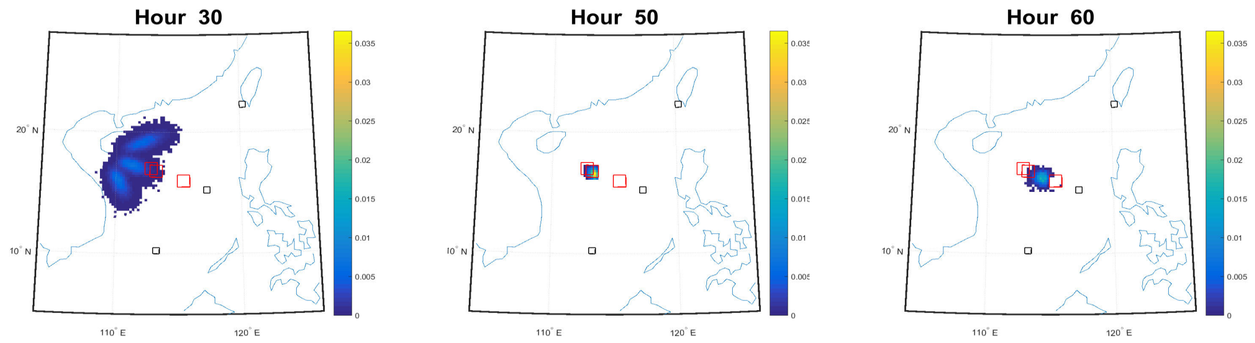
- Brownian bridge is a stochastic process where Brownian motion is tied to particular values at two points
- Captures at an aggregate level characteristics representative of weather and some level of tactical behaviors
- Used extensively in animal movement studies
- Modeled using simulations in MATLAB



Example of a Brownian Bridge

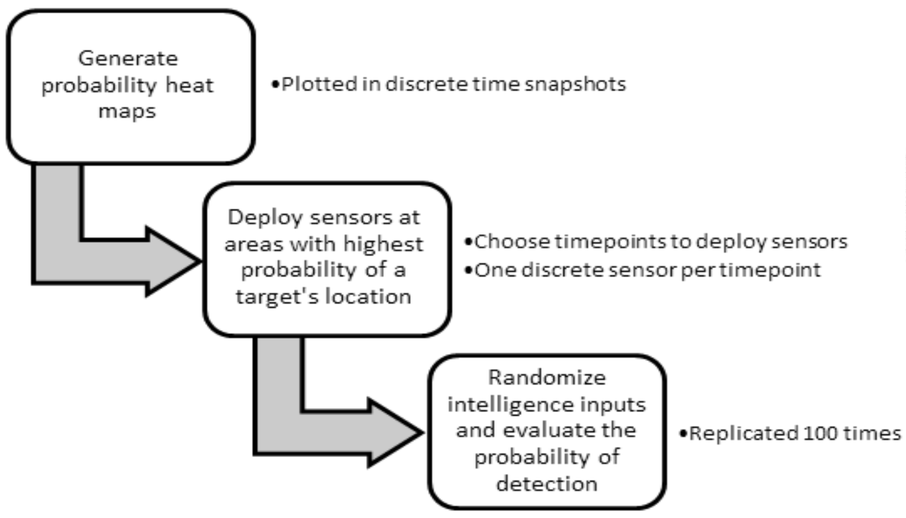
Probability Heat Map

- Calculated based on simulations of Brownian Bridges
- Based on time and x,y coordinates
- Can be extended to include multiple starting and ending points, updates with real intelligence
- Used as a means for sensor deployment



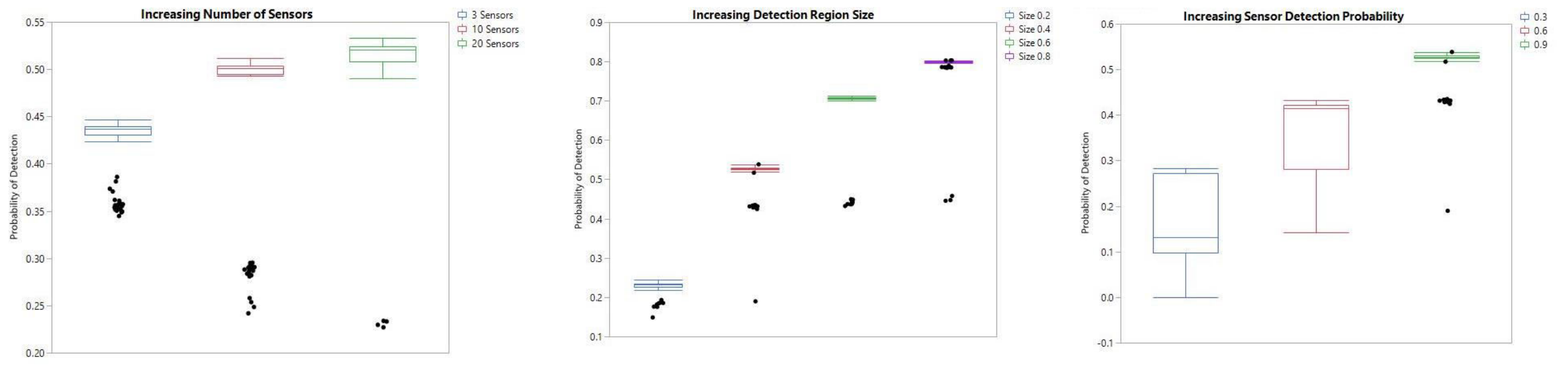
Example of Probability Heat Maps across time

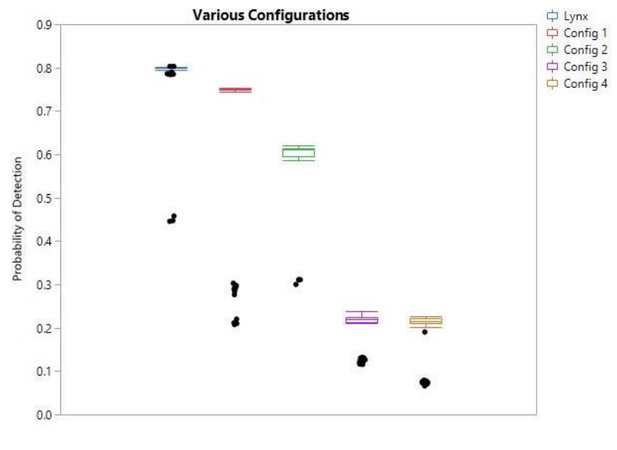
Meta-Experiment



- To see various aspects of sensors attributes and their effects on Pd
  - Number of Sensors
  - Sensor's Detection Probability
  - Detection Region Size
- Trade-off analysis between number of sensors vs detection region

Results





Configurations	Mean	Lower 95% CI	Upper 95% CI	Std Dev	Std Error Mean
Benchmark, based on Lynx multi-mode radar and 10 discrete sensors	0.7876	0.7757	0.7995	0.0598	0.00598
Configuration 1: 15 discrete sensors, sensor width of 0.7	0.6821	0.6487	0.7155	0.1682	0.0168
Configuration 2: 20 discrete sensors, sensor width of 0.5	0.5962	0.5843	0.6080	0.0598	0.00598
Configuration 3: 30 discrete sensors, sensor width of 0.2	0.2031	0.1953	0.2109	0.0392	0.00393
Configuration 4: 125 discrete sensors, sensor width of 0.2	0.1987	0.1890	0.2084	0.0489	0.00489

Conclusion:

- Developed the Brownian Bridge Movement Model with extensions and modifications for a military scenario
- It is more effective to have ***sensors cover a wider area at fewer discrete points in time*** than to have a greater number of discrete looks using sensors covering smaller areas
- Further work to extend the BBMM for continuous looks and smarter deployment algorithm

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