Radiation Detection in Half-Life 2

Virtual Environments for Developing Strategies for Interdicting Terrorists Carrying Dirty Bombs

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Stop terrorists from exploding radiological weapons over critical spaces

Stop terrorists with dirty bombs in backpacks

Courtesy of thingsyoushoulddo.com

Real Scenarios

- Terrorists trying to smuggle radioactive material into the United States
  - Police in Slovakia and Hungry arrested three men for trying to sell “dangerous” radioactive material (*CNN.com, November 29 2007*)
- Radiation detectors are triggered much too frequently by false positive at sea ports
  - U.S. is greatly increasing its monitoring of foreign cargo for radioactive response (*LA Times, November 25 2007*)

Challenges

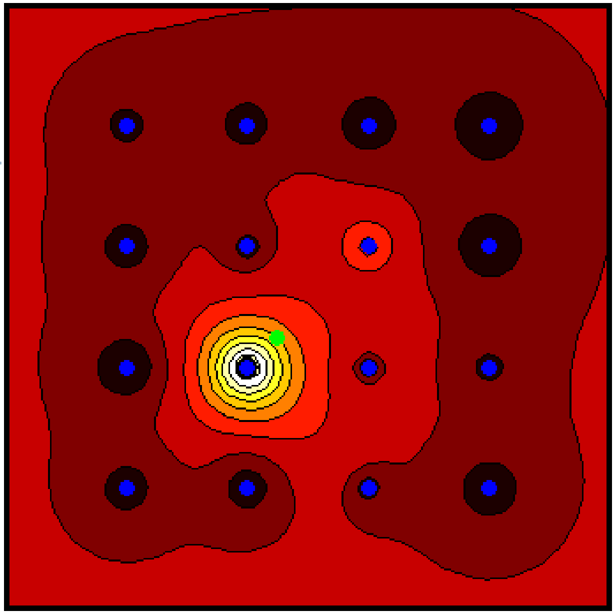
- How do we interdict a terrorist before he sets off a dirty bomb?
  - How should the radiation detectors be deployed?
  - What's the optimal strategy for a team of mobile sensors to detect one or more moving radiation sources?
  - Can stationary sensors on traffic lights or lampposts help?
  - How can false positives be limited?

IPRL handheld detectors developed at the Caltech

M. Chandy, C. Pilotto, R. McLean
Network Sensing Systems For Detecting People Carrying Dirty Bombs

Related Works

- Studies of sensor network (M. Chandy, C. Pilotto, R. McLean)
  - Estimating the position of a static source within a bounded area



Probability of a bayesian update without noise in the first 10 seconds

- Cell phone sensors detect radiation to thwart nuclear terrorism (E. Fischbach, J. Jenkins, Purdue University)
  - Sensor network constructed using the global positioning locators built-in in cell phones
  - Can detect weak source as far as 15 feet away

Purdue University News, http://news.uns.purdue.edu/x/2008a/080122FischbachNuclear.html

Defense Against Creative Enemies

- Our enemies may not behave the way we think they will
  - Traditional computer simulation doesn’t give much insights
- To deal with creative enemies we develop systems with teams of terrorists and security personnel playing against each other
- Our solution: A multi-player virtual gaming environment!

Requirements

- Realistic representation of the environment
  - Must be able to mimic correct physics in real world
  - Airports, sea ports, Rose Bowl, …etc
- Representations of radiation sources, agents, and robots
  - We assume that terrorists are on foot with lightly shielded radiation source
- Global virtual environment
  - Enable collaboration of many agencies

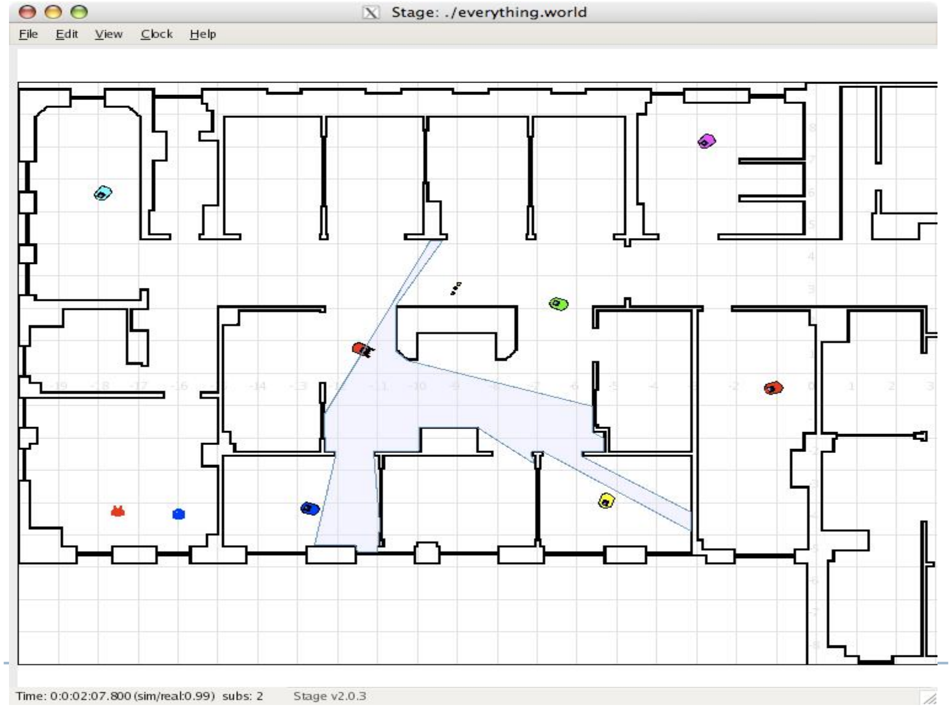
Platforms Studied

- Second Life
  - Popular online virtual community
  - Easy to access and collaborate within
  - Most realistic representation of the real world
  - Drawback: Limited API

Simulating photon hit probability in Second Life

Platforms (cont.)

- Player/Stage
  - Multi-robot controller server and environment emulator
  - 2D bitmapped environment
  - Most realistic choice to encode strategies for autonomous agents
  - Drawbacks: No means of user inputs



Autonomous agents maneuvering in Player/Stage

Platforms (cont.)

- Half-Life 2
  - The source code is available for each copy of the Half-Life 2 game
  - Optimized game, physics, and graphic engines that are capable of handling large amount of calculations required for photon simulation
  - Well-documented API and plenty of community support
  - Abundant resources available
  - Best option of all three

Autonomous agents having identified the radiation source and taking photographs of the suspect.

Accomplishments

- Photon simulation and detection
  - Photons are generate and detected in a Poisson manner
- Absorption of photons
  - Photon intensity decreases exponentially when encountering objects
- Background radiation
  - Different materials emit different levels of radiation, which is determined by : $\sum_m p_m.g_m.A$
- Heat map generation
- Mobile sensors

Radiation Model

- Sensor intensity:

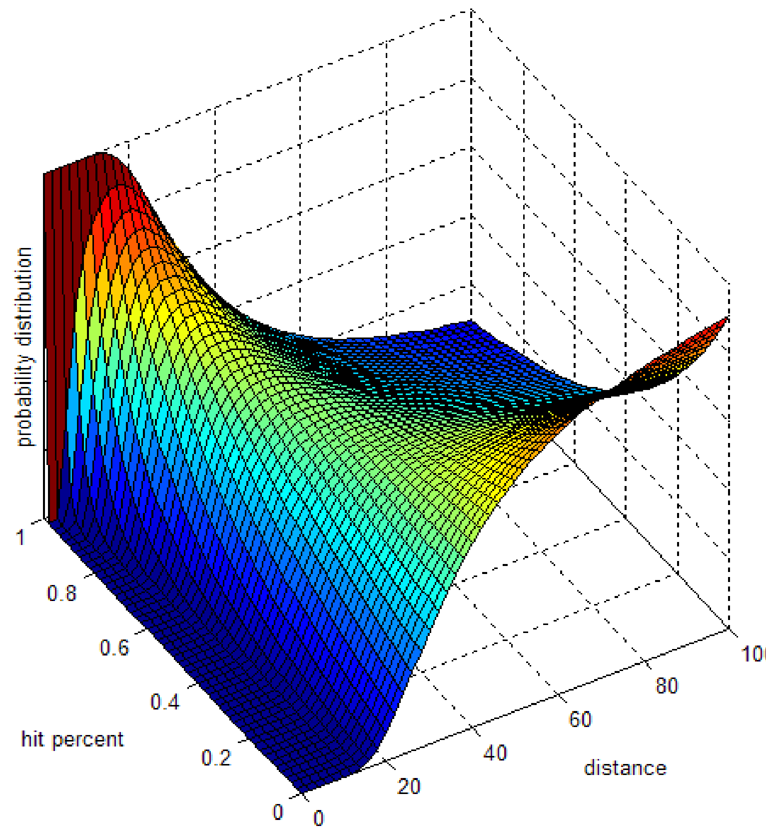
$$\lambda = \frac{\mu A \cdot \cos(\theta)}{4\pi d^2}$$

- Probability of detecting at least one photons in t seconds

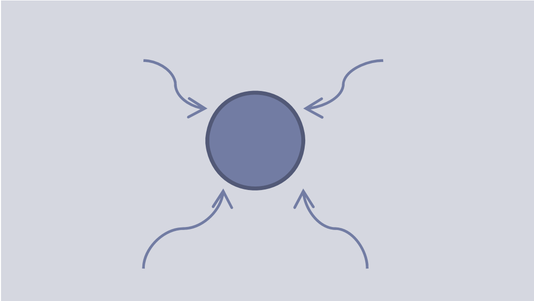
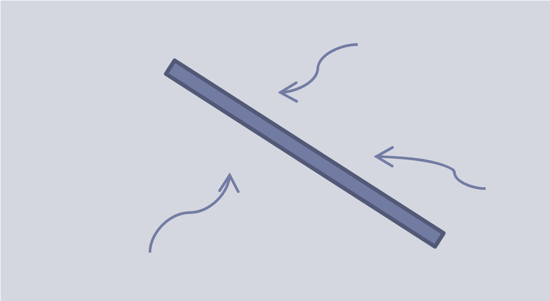
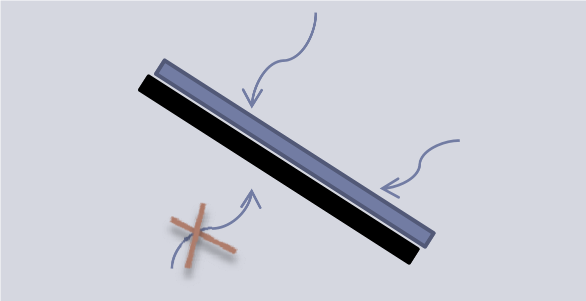
$$P(t) = 1 - e^{-\lambda t}$$

- Graphics explanation for $\lambda \sim \frac{1}{d^2}$

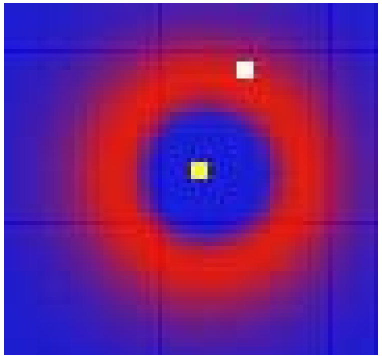
- Joint radiation probability distribution given intensity

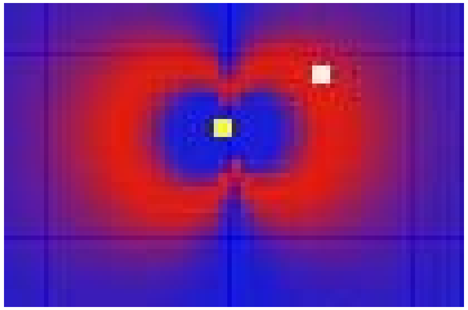


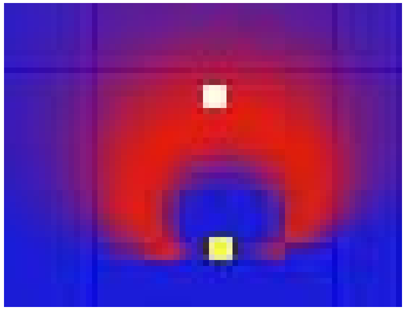
Various Detector Models

Spherical Intensity (I) $\sim 1/d^2$	Unshielded flat panel $I \sim |\cos(\varnothing)/d^2|$	Shielded flat panel $I \sim \max(\cos(\varnothing)/d^2, 0)$
		

Heat map generated given stationary detectors of different models







Future Directions

- Rapid interdiction
  - Optimal mobile agent algorithm
- Photon detection without assumption of source intensity
- Implement sensors that can detect different signatures of radiation isotope
- Algorithms for detecting mobile radiation sources

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