Remote Access For Mobility via Virtual Micro Security Perimeters

Argus: Smartphone-enabled Human-robot Cooperation for Disaster Situational Awareness

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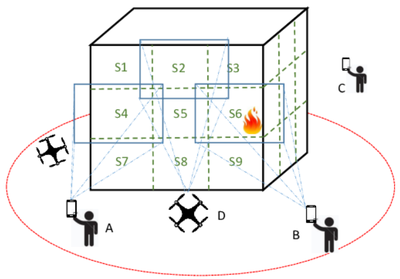
Introduction and Motivation

- Disaster Management
- Situational Awareness
- Challenges: coordination, lack of detailed incident information and poor data consolidation

Existing Approaches

- Complex incident reporting to authorities (witness testimony)
- Fail to provide information ahead of time for proper rescue planning
- Do not leverages valuable on site information: first-hand, real-time, local, fine-grained image and audio based incident zone reconstruction
- Do not protect the agents privacy during data consolidation

Our Approach: Overview



- Argus (mobile app) uses the information from “witnesses”
- Provides a framework for human-robot collaboration using Multi-Agent Reinforcement Learning (MARL) with privacy preserving

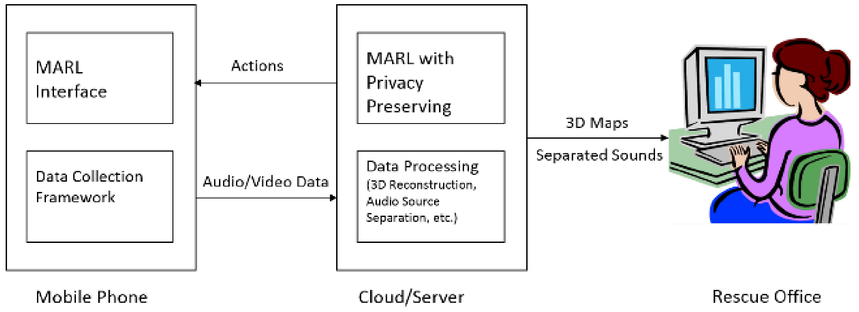
Privacy Preserving Data Consolidation

- 3D maps of disaster scene with high clarity critical regions
- Audio source separation to prioritize regions

3D Reconstruction Advantages

- Fusion: Many images/videos difficult to process one by one
- Depth: Able to locate fire, victims and other objects accurately
- No Redundancy: Images of the same scene from different views is needed in 3D reconstruction
- Much cheaper than other techniques such as 3D scanners.

Our Approach: Architecture



Privacy Oriented Framework

- User controlled selection of data collected and reported
- Time and Location aware reporting
- MARL with privacy preserving features and Data processing engine
- Privacy preserving using LTL (Deterministic Rabin Automaton) and MDP

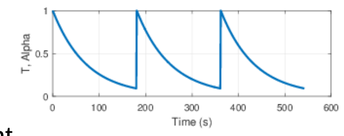
$$\phi := true|a|\neg\phi|\phi \wedge \phi|X\phi|\phi U\phi|G\phi|F\phi$$

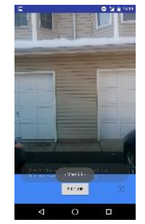
Machine Learning Driven Data Collection

- States – cells in the grid; Rewards - % of fire pixels in images captured
- Distributed Q-learning where all agents share same Q-values

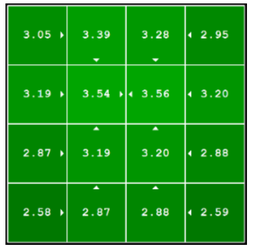
$$Q_{t+1}(s_t, a_t) \leftarrow Q_t(s_t, a_t) + \alpha[r_t + \gamma max_a Q_t(s_{t+1}, a) - Q_t(s_t, a_t)]$$

- E.g., 25% Exploration; 75% Exploitation
- <u>Periodic Exploration</u>: To capture dynamicity of the environment





Evaluation

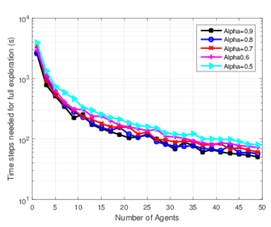


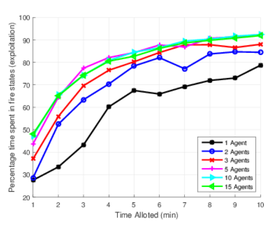
Extracting an Optimal Model

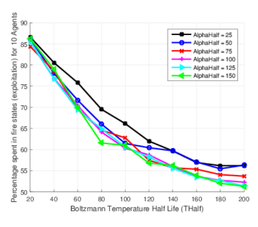
- Fire states have high value functions at convergence
- Exploration time reduces with more agents.
- More time spent in fire states with more agents
- $Alpha_{half} = T_{half} = 50$ for 75:25 exploitation:exploration

Dynamic Model

- Periodic Exploration that enables to capture the evolution of the incident over time.
  - Monitoring the evolution of the fire
  - Detecting separated areas of fire







t_1 :

S1	S2	S3	S4
S5	S6	S7	S8
S9	S10	S11	S12
S13	S14	S15	S16

0.80	0.27	0.24	0.24
26.31	0.93	0.27	0.27
57.30	3.76	0.32	0.25
7.31	1.03	0.45	0.27

t_2 :

S1	S2	S3	S4
S5	S6	S7	S8
S9	S10	S11	S12
S13	S14	S15	S16

3.31	50.54	27.97	1.75
0.95	3.16	1.45	0.57
1.43	1.20	0.89	0.66
2.65	1.69	1.03	0.75

t_3 :

S1	S2	S3	S4
S5	S6	S7	S8
S9	S10	S11	S12
S13	S14	S15	S16

0.82	0.65	0.46	1.74
0.99	0.79	1.96	35.39
1.49	1.21	2.78	44.71
2.40	1.37	0.81	2.44

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