A CONTRIBUTION TO THE INFRASTRUCTURE OF THE RESCUE SIMULATION COMPETITION
HISTORY OF UVA-RESCUE AND AOJRF

- UvA-Rescue is active in the Rescue Simulation League since 2003.
- Several infrastructure contributions over the years:
  - Smoke visible to the laser scanners
  - Omnidirectional camera
  - Validated walking robot
  - Validated flying robot
  - Upgrade from UT2004 to UDK
THE DETAILED MAPS BY THE TEAM
IDEAS OF UVA RESCUE FOR THE INFRASTRUCTURE COMPETITION

- Uniform Robot Description Format
- Ricoh Theta
- RoboCup@Home Simulation
- KUKA youBot
- Observations while moving
A SIMULATOR WITH A DETAIL LEVEL BETWEEN THE AGENT AND VIRTUAL COMPETITION

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RoboCup Rescue Simulation Infrastructure Competition, João Pessoa, June 22, 2012

Universiteit van Amsterdam Intelligent Systems Laboratory
Role-Based
Multi-Robot Exploration

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RESULT: A 2D ROBOT SIMULATOR (VERSION 2.0)
CONTEXT

- High-bandwidth communication is limited
- Emphasis on cooperation strategies under the constraints of limited communication
ROLE-BASED EXPLORATION

- Agents assigned one of two roles:
  - Explorer
  - Relay
- Explorers explore new frontiers, bring information back to rendezvous points
- Relays move information between base station and explorers
- Agents can swap roles in the tree, but the tree structure doesn't change
ROLE-BASED EXPLORATION

- Explorer starts exploring, relay follows

- Once they are outside communication range, they pick the next rendezvous point (nearest to next frontier, within safe space), relay goes back to base

- Explorer estimates how long it would take the relay to return to the rendezvous point; stops exploring and returns to RV at the right time
SWAP ROLES

- Agents can swap roles if it would reduce travel time.
- Swapping roles leads to emergent behaviour, where relays can form longer chains not explicitly defined in the relationship tree.
RENDEZVOUS POINT SELECTION

- Rendezvous point selection has a crucial effect on team behaviour
- RV points closer to base station lead to more frequent updates; closer to frontiers leads to faster exploration
- Good to pick points near frontiers but in open space (corridors, junctions)
- Get a skeleton of the environment, select points at junctions, remove points too close to others, fill in gaps, select best point
NOW: OPEN SOURCE & VERSION 2.2
Multi-Agent Exploration in Indoor Environments with Limited Communication

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Doesn't take into account communication range
- Robust to communication problems
- But can be very inefficient

What if the robots planned to communicate through obstacles?
- Need to select rendezvous point pairs – how?
- What to do if communication does not happen?
WHAT ARE THE CANDIDATE RV POINT PAIRS?

- We want point pairs that have an obstacle between them (no line of sight comms)
- Using the point pair has significant advantage over using a single rendezvous point
  - We want the benefit to outweigh the additional risks introduced with lack of line-of-sight
GENERATING CANDIDATE RV POINT PAIRS

- Sample points close (but not too close) to obstacles.
  - Use several iterations of “thinning” to obtain a set of such points
  - Sample points from the set uniformly
- Evaluate communication range at each point (using a communication model with attenuation factor for walls); reduce the resulting range by a factor for additional safety
- Sample points from the communication polygon as candidates for the 2\textsuperscript{nd} RV point in the pair
  - Evaluate distance to base
FALLBACK

- Agents can estimate meeting time, and agree on a timeout.
- After the timeout, they can proceed to the single rendezvous point as a fallback.
- Use low-frequency (low-bandwidth) high-range communication channel for control messages.
RESULTS

- Improved team connectivity
- Base station gets more frequent updates
- But, overall exploration speed not affected – as additional resources are not allocated to exploration
- Relays kept close to base station – safer, avoid going into risky areas, spend less time travelling
- Relays spend more time idle – may allow us to convert some relays into explorers, as fewer relays may be required
PAPER II

DYNAMIC ROLE SELECTION

- Favour different metrics: overall time VS connectivity

[Graph showing comparison of different methods over time]
PROPOSED METHOD

- Set the desired minimum ratio of total agent knowledge known at base station
- Control team behaviour with a single parameter, a real number between 0 and 1
IMPLEMENTATION

- User sets $targetInfoRatio \in [0; 1]$

- For each agent $i$,
  - $infBase_i$ is the information $i$ believes the base station to have
  - $infNew_i$ is 'new' information $i$ knows

- Each agent either exploring, or returning to base

- An agent $i$ only decides to return if
  $$\frac{|infBase_i|}{(|infBase_i| + |infNew_i|)} < targetInfoRatio$$
IMPLEMENTATION - RELAYS

- Agents delivering same information to base = wasted resources
- When two agents, $i$ and $j$ meet, and $j$ closer to base
  - $\infNew_{i}$ added to $\infNew_{j}$, $\infNew_{i}$ set to 0
  - $\infNew_{i}$ is marked as “being relayed”
- Reduce the risk of several agents trying to deliver the same information to base
EVALUATION

- Evaluated in a 2D simulator
  - Assumed perfect localization and mapping
- Used target ratios of 0.95, 0.90, 0.75, 0.5 and 0.3,
- Compared with Role-based exploration; tried with 4 and 8 robots
- 4 maps, 4 runs on each map for each configuration
RESULTS
EMERGENT BEHAVIOUR

- All agents start off as explorers
- As exploration moves deeper into the environment, dedicated relays emerge
- Relays create relay chains, as they navigate towards “popular” frontiers, plan similar paths and meet other relays on the way
Video
RESULTS

- A simple, effective way of specifying desired team behaviour and having the team adapt, by changing a single numerical parameter
  - Need to test in a realistic simulator and on a team of real robots
  - Which target ratios should be used for any particular situation
  - Bigger environments, more robots
CONCLUSIONS

• The MRESim Simulator is a Java based Open Source Simulator.
• Robots / Agent have a limited field of view, resembling a laser scanner (without noise)
• Robots / Agent have a limited communication range, attenuated by walls (like the WSS)
• Robots have to be distributed over the map
• Cooperation can be modelled by combining robots in explorer / relay pairs

https://github.com/v-spirin/MRESim