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ARC Centre of Excellence for
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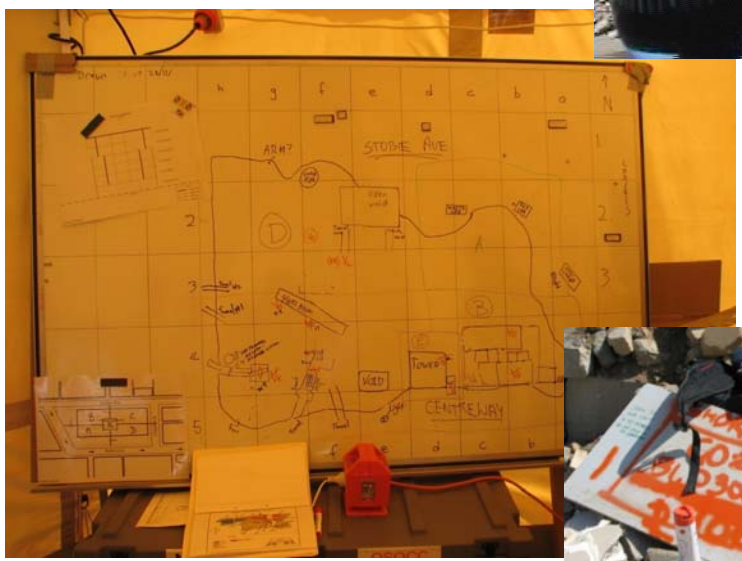
Systems

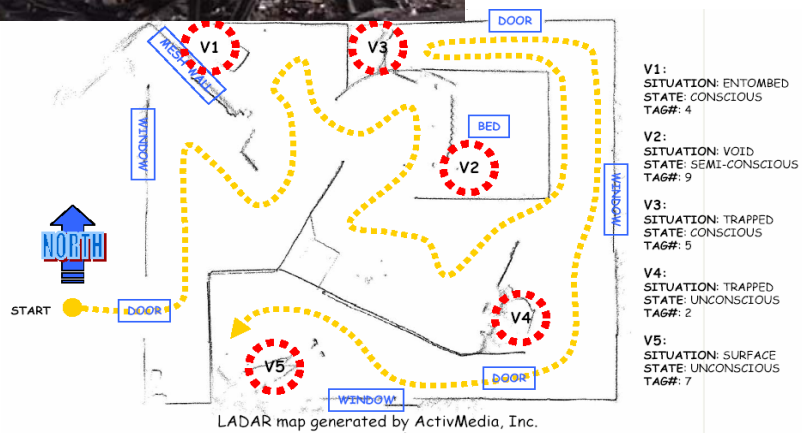
Robot Assisted
Urban Search and Rescue (USAR)

motivation

- to what extent can robotic platforms and sensors aid rescuers in collapsed USAR (man-made) scenarios?
  - other disaster areas (mine rescue, wildfire …) not covered
- lessons learnt from past disaster interventions
- overview of current robot, sensor and state-of-the-art propositions
  - the practical and the wacky ones!
  - the industrial and the more academic ones

urban search and rescue





problem

- navigate unstructured & hazardous environments
- become aware of disaster site
  - size up incident
- locate survivors
- main task is “search”
  - not shoring or victim extrication

role of mobile robots in USAR

- aid in reconnaissance and confined space traversal
- rescuer protection
  - mitigate unknown hazards
- victim id
- decrease response time, increase survival rate
  - generally no single-robot solution but multi-agent

- overall, challenging integration problem of
  - locomotion
  - perception
  - mapping
  - localization

research problems

- locomotion
  - wheels, legs, tracks, UAV, snake …
- sensing, localization and mapping
  - LADAR, sonar, GPS, vision, IR, IMU, gas sensors …
  - 3D SLAM
- heterogeneous multi-agent co-ordination
- easy deployability + full task automation
- interaction issues robot-rescuers: HRI
- learning

robots for USAR - early days

- first known actual use of robots for USAR: World Trade Center disaster on 9/11/2001
  - still at its infancy
- robots were employed in (www.crasar.org) :
  - searching for victims
  - searching for paths through rubble that would be quicker to excavate
  - structural inspection
  - detection of hazardous materials

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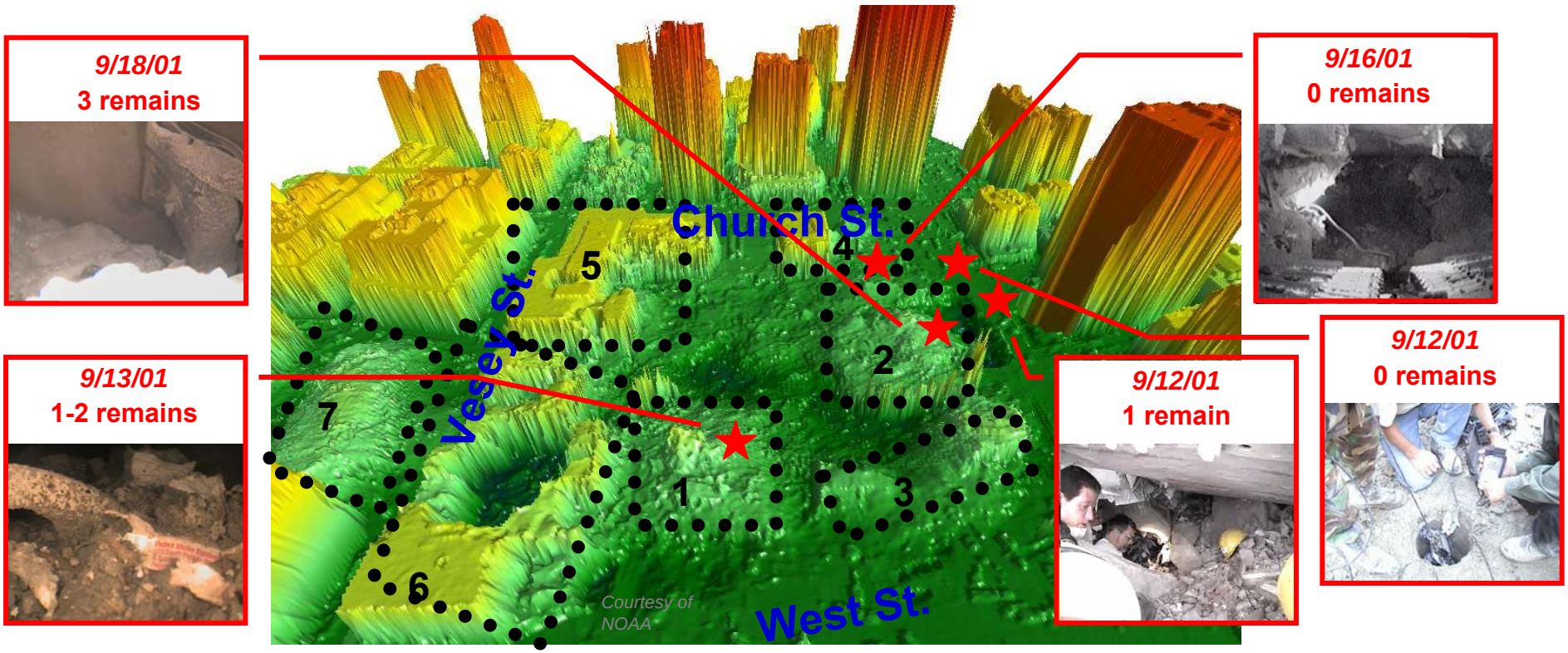
deployed robots at the WTC disaster







WTC: where robots were during rescue phase



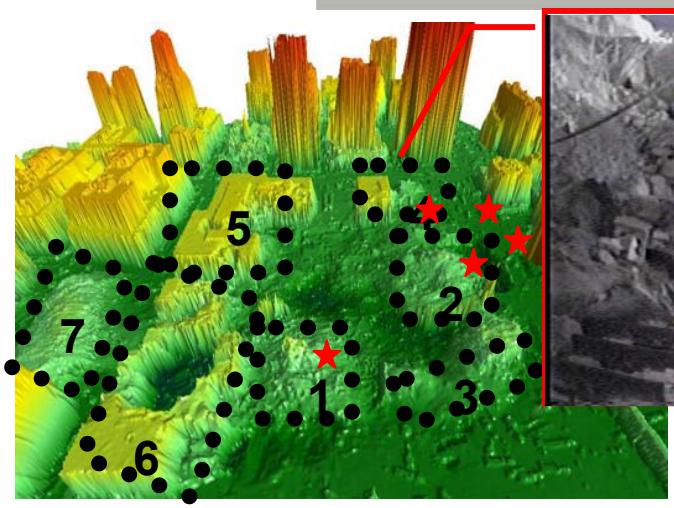
(courtesy of crasar.org)

- tethered tele-op robots used in 6 drops
- No survivors found. 2% (10) of victims found by robots

robots were employed because …

- could go deeper than traditional search equipment
  - robots 5-20 meters into the interior of rubble pile
  - ~ 2 meters for a camera mounted on pole
- could enter a void space too small for a human or search dog
- could enter a place still on fire or posing great risk of structural collapse
- quite importantly: were readily accepted by the rescue community.
  - yet all teleop due to same user acceptance issues (amongst others)

many lessons learnt



Courtesy of NOAA

(Oklahoma city bombing)

- information fed back by robot is most important
- voids will be searched by persons if possible
- It's not about navigating over rubble but getting into the interior
- man-packable
- teams of 2 people/robot best

size robot vs. size void

(see www.crasar.org for more details on taxonomy)

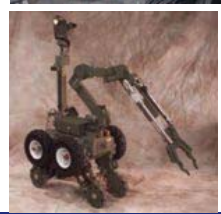


	Semi-Structured	Confined Space	Sub-Human Confined Space
Man-packable: Micro			
Man-packable: Mini			
Man-portable			
Maxi			

Shoebox sized
Tethered
Esp. good for vertical

Carry-on sized
wireless
Most climb stairs

Lawnmower sized
wireless
May have arm,
Can do rapid hazmat



EOD bomb squad
Shoring, extrication

wonderful creations for disaster area robot locomotion

CMU - RHex rocky outcrop.mpg

CMU - RHex swim.mpg

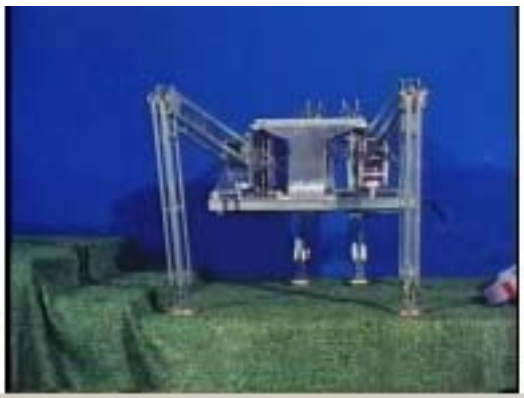
CMU - MiniWhegs.mpg

CMU - CarpetMonkey stairs USAR.mpg

more on robot locomotion

Hirose lab Tokyo - Genbu (firehose).mpg

Hirose lab Tokyo - Roller-Walker.mpg

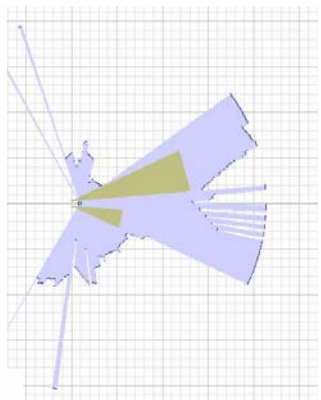


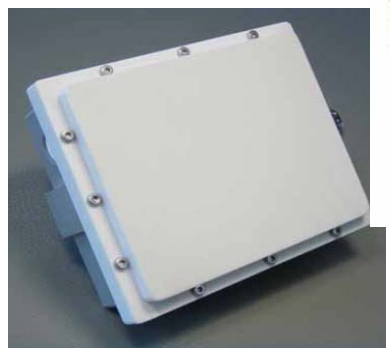
Hirose lab Tokyo - 4 leg walker PV-II_w .mpg

John Deere - Plustech Oy walker.mpg

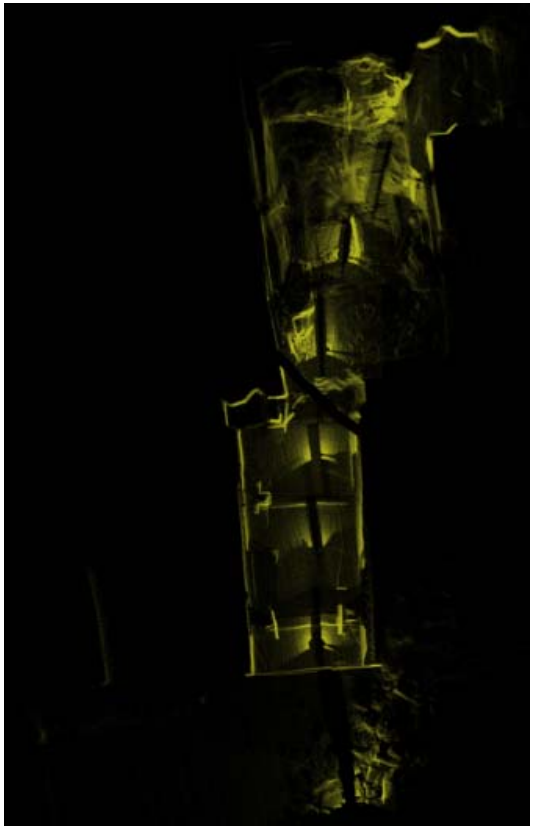
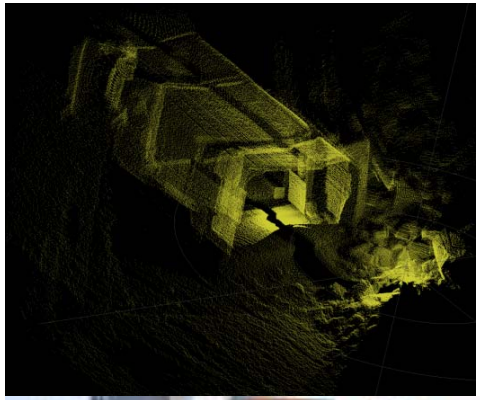
iRobot-Packbot Explorer.mpg

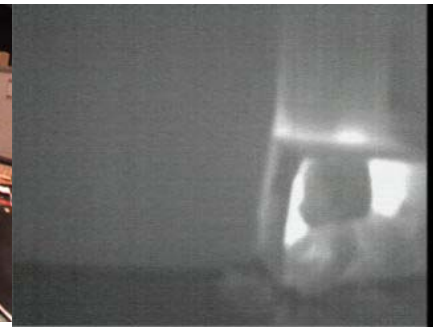
multitude of sensors available

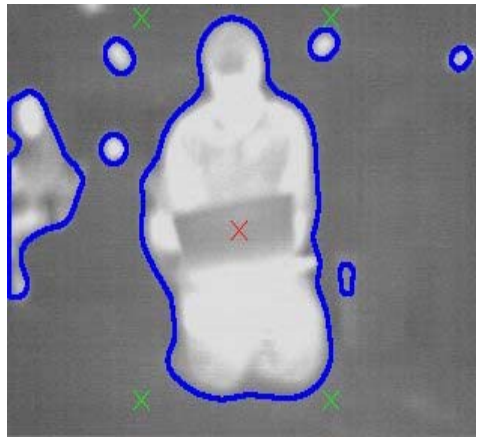




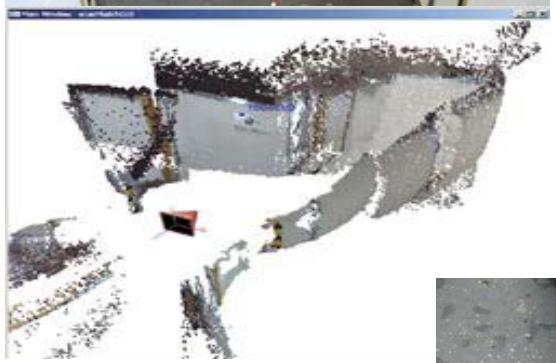
sensors to the aid: sensor fusion

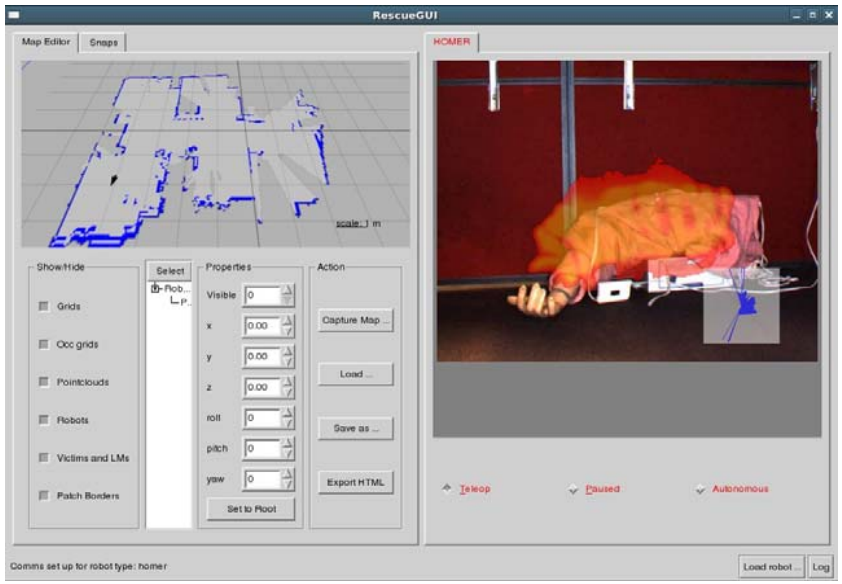



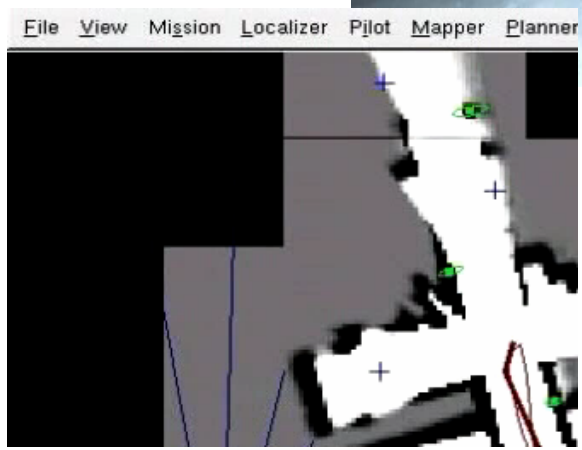




sensor fusion (cont)







collaboration

- researchers – emergency workers – industry cooperation key for suitable emergency response development
- information sharing
- standards for training – NIST RoboCup Rescue

Fire brigade (rescue/USAR section) training site, Adelaide

NIST Rescue arena

conclusions

- Robots have potential to become accepted successful rescue tools such as dogs
  - firies/rescue workers already generally tech-savvy
- Reconnaissance, confined-space, victim location are already achievable with today's robots and sensors
- No current "one-size fits all" rescue robot solution
  - wide size/capabilities/robustness/objectives
- Despite advances in sensors (hardware, fusion…), still not sufficiently adequate to fully exploit all surrounding information
- Additional "intelligent" capabilities necessary to make the move into rescue departments:
  - clever autonomous navigation, object id within a context, better HRI, multi-agent (robot/rescuer) coordination
- Cost needs to come down significantly for wide-spread usage and deployment