TEAMS OF ROBOTIC BOATS

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CHALLENGE: **MAXIMIZE** THE AMOUNT OF USEFUL KNOWLEDGE IN THE AVAILABLE TIME **USING ROBOTS**
INFORMATION COLLECTION

• Take noisy, temporal samples
  • Go to a location for sampling
  • Create a model
  • Use model to decide where to sample next

• Robots can achieve:
  • Intelligent sampling
  • Spatial, temporal density
  • Vigilance
  • Repetition
  • (i.e., dull, dirty, dangerous)
DO IT WITH REAL ROBOTS

- World has interesting, complex structure that can be exploited
  - Hard to capture real distributions
  - The “real” problems are sometimes not the ones we study
    - E.g., communications patterns
- Absolutely a role for simulation, highly constrained environments
GO INTO THE FIELD

• Take the robots into real environments, let them loose!
  • Prioritize research challenges

• Field is not necessarily harder
  • Sometimes it lets you throw away overly broad assumptions

• Design something that works in at least one place
BIG TEAMS

• Once we have one reliable robot, having many is easily possible

  • Prices will fall precipitously

• Allow: Temporal, spatial, vigilance, redundancy, reactive

• Not swarms

  • Not necessary, not obviously useful for information collection
Unmanned aircraft looking for radio signals or lost hikers or cows
Robot looking for a dog toy
TOO MUCH TIME SPENT MAKING ROBOTS WORK

NOT ENOUGH TIME ON APPLICATION AND COORDINATION ISSUES

NEED TO BE TOO CAREFUL
GOING INTO THE FIELD WITH A DIFFERENT ATTITUDE

• Let’s lose some robots
  • Safe, unbreakable or don’t care

• Let’s go every day
  • One or two students

• Let’s do the first test of an algorithm in the field
Autonomy

Complexity

Rod Brooks

X

Autonomy
PROBLEM

• Large areas get flooded every year
  • Often poor countries with few resources
• First responders struggle with:
  • Dirty, dangerous water difficult to get around
  • Victims spread over very large area
• AIM: Identify victims, either get help or send urgent emergency supplies
ROBOT BOATS

• Robust, safe
• Low-cost
• Easy to deploy
• Simple regulation issues
• Robotic technology is easy

• Lots of water, lots of boats make sense
  • Even densely
• Sparse knowledge of water
• Complex spatial, temporal processes
• Relatively hard and expensive for people
ROBOTIC BOATS: BEEN DONE ... NOT HARD
PHILIPPINES

Taken from boat
$1.5M dead fish, due to an unanticipated drop in oxygen levels (the fish drowned)
WATER TEMPERATURE IN LAKE TAAL

Before rain

After rain
TEAMS OF ROBOT BOATS:

- INTERESTING DOMAIN
- GOOD PLATFORM FOR RESEARCH
HARDWARE CHALLENGES

- Reliability, simplicity
- Stock components
- Extensibility, flexibility and usability
  - Iterative architecture design
- Transportability
- Very low cost
- “Deployability”
- Safety
- Manufacturability
HARDWARE DESIGN

• Airboat design for shallow water, debris
• Two moving parts
• < $2000
• ~10 hours to construct
ANDROID PHONES

- GPS
- IMU
- Computer
- Powerful IDEs

- Wireless, 3G
- Battery life
- Robust
- Very low cost
Sensor placement (Thrun et al)

Mobile robot planning for information (Dolan et al)

Active sensing/learning (Schnieder et al)

Large teams of real, unreliable robots in real environments

Practical information gathering by robot teams

Background

Constraints

Contribution
CONTROL

Asymmetry of boat trajectory under 'uniform' translational current/wind disturbances could be caused by the inherent asymmetry of the boat hull, which makes the specific boat tend to turn LEFT (CCW dir) naturally.

steady-state error between boat velocity direction & boat heading

steady-state error between boat heading & desired heading
MOTION PRIMITIVES
VISUAL OBSTACLE AVOIDANCE

Reflection Detection (removes clusters containing reflections)

Features: 75

No avoidance
Sparse Optic Flow

Clustering

Reflection Detection (remove clusters containing reflections)

Occupancy Grid

Final Processed Frame (with annotations)

Speed up to work on a phone
Reduce noise
Glassy water
Individual frames are noisy
SENSING WATER

- Complete map
- Level set
- Event
- Maximum/minimum
WHAT SENSORS?

- Camera
- pH, temperature, oxygen, dissolved solids, bromide
- Depth, currents, vegetation
EXAMPLE MODEL ERROR

One boat

Four boats
User Interaction
GOING FORWARD:
LONG TERM OPERATION
USING CURRENTS

• Travel long distances by using the current, not the engine

1. Find river on map
2. Go to middle of river
3. Turn off motor
PLAN TO AVOID CURRENTS

• May plan to avoid currents when going against

• Straight line might not be the most efficient

• Use level set expansion to plan
RECHARGE STATION

- Allow long-term deployment, daily monitoring
- Two stations near locations impacted by storm water runoff
  - Soon!
- Great AI challenges
  - (with Mel Siegel)
WHAT HAVE WE LEARNED?

• Current technology is useful
  • I.e., Alex’s “Remaining Years R&D for Essential Capabilities” is misleading

• We don’t know the killer apps

• Business pressures are different (should we care?)

• Design, build, test, transport, train, use, repair, repurpose
  • We typically only care about first two, is that right?
CONCLUSIONS

• Robotic boats are a great platform for multi-robot research

• Information collection is a high-complexity AI challenge

• Just scratching the surface
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