TEAMS OF ROBOTIC BOATS

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CHALLENGE: <u>MAXIMIZE</u> THE AMOUNT OF USEFUL <u>KNOWLEDGE</u> IN THE <u>AVAILABLE TIME</u> 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

Rod Brooks









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



LAKETAAL FISH FARM





\$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

SOFTWARE DESIGN



Sensor placement (Thrun et al)

> Mobile robot planning for information (Dolan et al)

Large teams of real, unreliable robots in real environments

Practical information gathering by robot teams

Active sensing/ learning (Schnieder et al)

Background

Constraints

Contribution

CONTROL







MOTION PRIMITIVES





Motion Primitive Test - 2

VISUAL OIDANCE



within it

Reflection Detection clusters containing reflections)





SENSING WATER

- Complete map
- Level set
- Event
- Maximum/minimum





WHAT SENSORS?

- Camera
- Ph, temperature, oxygen, dissolved solids, bromide
- Depth, currents, vegetation

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			Upper 85.0 Lower 75.0 Context All auto
			Boat@Unknown

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
- I. Find river on map
- 2. Go to middle of river
- 3.Turn off motor



PLANTO AVOID CURRENTS

30 20 10

-10 -20

-30

- 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)



www.senseplatypus.com







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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