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Udacity AIND Build a Game-Playing Agent
Paper Report

The paper selected is:
Rational Handling of Multiple Goals for Mobile Robots
Richard Goodwin and Reid Simmons, Carnegie Mellon University 1993

This paper is available here:
https://pdfs.semanticscholar.org/35ab/2ccb30a70ac4db883386b8442329980bbdeb.pdf

I selected *Rational Handling of Multiple Goals for Mobile Robots* because it talks about a difficult problem in artificial intelligence - choosing between actions serving multiple goals. In this case, they had a "Hero 2000" robot in an office setting (section 4). The robot performed two duties: delivering printer results to desks, and empty cup collection. It also needed to avoid running out of battery by keeping itself charged.

Utility Function

Generally people select between multiple actions by using the "benefit/cost ratio". That is, select which action provides the most benefit per cost (section 2.1). This is intuitive and natural, but doesn't work perfectly here. Consider this case

Energy remaining: 10 energy units
Cup removal benefit: 1 benefit units
Printer delivery benefit: 5 benefit units
Cup removal cost: 1 energy
Printer delivery cost: 10 energy

Given the above, cost/benefit will choose to remove the cup, but then the robot won't be able to deliver the printer job. This means we've missed out on a much larger benefit with the greedy cost-benefit selection.

To resolve this, the paper introduces the concept of using net-present-value. The key difference is net-present-value chooses to maximize the total return, instead of the rate of return. This would cause the robot to realize that if it selected the cup removal, it would miss out on the printer delivery and 4 units of benefit.

Net-present-value can be more difficult to use, mostly because the cost and the benefit need to be expressed in the same units. In this case, they ended up using "saved human time" as their unit (section 4).

Action Plan Selection
The difference here vs. typical planning is that new opportunities can arise suddenly. A human can start a new printer job, which could result in an interruption of a current cup removal to go fetch the job, assuming the utility was higher.

For the Hero 2000 robot, they explicitly designed an "on-the-way" plan to accommodate some of these types of requests. They also limit the number of plans considered by only considering a subset. This means the best possible plan might not be selected, but it avoids the robot standing still and computing instead of working!

Robot Choices vs. Human Choices
The paper did a comparison of how the robot chose what to do vs. what a human chose. Generally the results were quite comparable, but there was one interesting difference. Humans would often go and recharge even when there was some outstanding work to do. This was in anticipation of a burst of work in the future, something the planner did not account for.

Conclusion
While this is an older paper (almost 25 years!) it still provides a good overview of action selection given multiple, possibly competing goals with interruptions. This is clearly relevant for robots that perform generally house-keeping work, but could also see applications in industry settings where work is being generated from an uncontrolled source (e.g. customer orders).