Lecture03b: Meta-heuristic Search (& Practice Reading a Paper)

CS540 2/118

Announcements

On-campus students:
- Make sure I am wearing the microphone
- We are going to keep using the 2nd microphone for questions

All students:
- Project 1 is due Thursday, Feb 15.
- Teaming assignments emailed out this morning
  - Eleven teams, named Team A through Team K
  - Emails sent to your "official" email (as determined by AriesWeb)
- Are there questions?
- No paper this week – work on your projects!

Reading assignment #2 due today

Mobile robot path planning…

M. Contreras-Cruz, V. Ayala-Ramirez & U. Hernandez-Belmonte. *Mobile robot path planning using artificial bee colony and evolutionary programming.* Applied Soft Computing 30(2015):319-328.

Goal: shortest unobstructed 2D paths
- Given occupancy map
- Robot disk radius

Approach
- Artificial Bee Colony
- Evolutionary Programming

Why two? What role does each play?

ABC Algorithm

ABC = Artificial Bee Colony

1. Initialization phase
2. **Repeat**
3. Employed Bee Phase
4. Onlooker Bee Phase
5. Scout Bee Phase
6. Memorize Best Solution So Far
7. **Until** cycle = maximum number of cycles

Finding Paths with ABC

Initialization phase
- Randomly create list of free points
- Randomly assign "employed bees" to free points

Employed Bee Phase
- Evaluate points as $F_1(n) = \|V_n(x,y) - G(x,y)\| + f_{pen} \times p_n$
  - $f_{pen} = 2\sqrt{w^2 + h^2}$
  - p_n is a penalty (collision) counter
  - Why is F subscripted?
- Try one alternate position (like onlooker)

Onlooker Bee Phase
- Distribute onlookers according to $p_i = \frac{fit_i}{\sum_{j=1}^{SN} fit_j}$
- Each onlooker tests a variant of the food position for a random k:
  $v_{i,j} = x_{i,j} + \emptyset(x_{i,j} - x_{k,j})$
- If new position is better, employed bee moves

Finding Paths with ABC (cont.)

Scout Bee Phase
- When no improvement of a position after N trials, randomly reset it

Memorize Best Solution
- Self-explanatory

But how does this create a path?

Algorithm 2

Algorithm 2

1. C(x,y) = S(x,y)
2. **While** C(x,y) ≠G(x,y)
3. Best = CallABC()
4. P = Add(Best)
5. $C(x,y) = V_{best}(x,y)$
6. **End while**

They didn't label this.
What kind of search is it?

Evolutionary Programming

Algorithm 3: Evolutionary Programming

1. Initialize the population
2. **Repeat**
3. ~~Expose population to environment~~
4. ~~Compute fitness for each member~~
5. Randomly mutate each parent (producing children)
6. Evaluate parents and children
7. Select members of new population
8. **Until** some condition is met

Applying EP to Path Planning

Initialize the population
- They seem to start with a population of 1 from ABC

Evaluate population members

$$F(T) = \sum_{i=1}^{M-1} \|V_i(x,y) - V_{i+1}(x,y)\|$$

Select members
- Not described, but shorter paths should imply higher probability

Mutations

Delete : remove a vertex at random

Smooth: replace a random vertex with two vertices:
- One on the incoming edge
- One on the outgoing edge

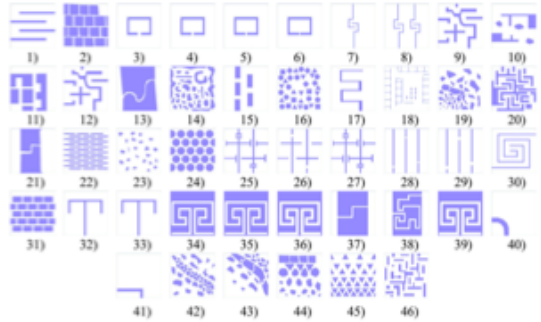
Update: replace a random vertex with a new random vertex

Visibility: Select two random vertices, remove all the vertices between them

Only non-oobstructed paths are permitted in mutations

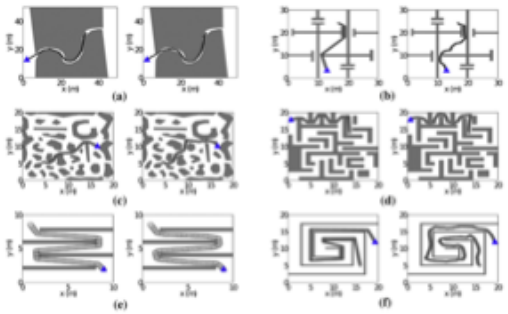
Probabilities: Delete 0.2, Smooth 0.1, Update 0.1, *Visibility 0.6*

Test Cases



M. Contreras-Cruz, V. Ayala-Ramirez & U. Hernandez-Belmonte. *Mobile robot path planning using artificial bee colony and evolutionary programming.* Applied Soft Computing 30(2015):319-328.

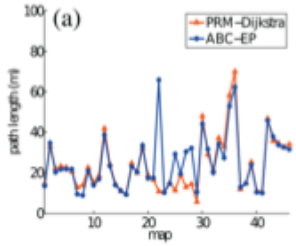
Selected Examples



M. Contreras-Cruz, V. Ayala-Ramirez & U. Hernandez-Belmonte. *Mobile robot path planning using artificial bee colony and evolutionary programming.* Applied Soft Computing 30(2015):319-328.

Results: Path Length

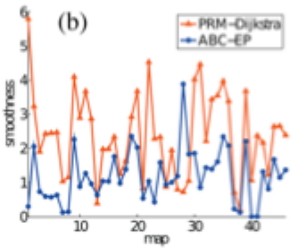
What do you conclude from this graph?



M. Contreras-Cruz, V. Ayala-Ramirez & U. Hernandez-Belmonte. *Mobile robot path planning using artificial bee colony and evolutionary programming.* Applied Soft Computing 30(2015):319-328.

Results: Smoothness

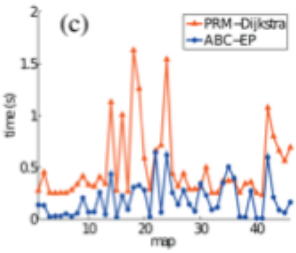
What do you conclude from this graph?



M. Contreras-Cruz, V. Ayala-Ramirez & U. Hernandez-Belmonte. *Mobile robot path planning using artificial bee colony and evolutionary programming.* Applied Soft Computing 30(2015):319-328.

Results: Run Time

What do you conclude from this graph?



M. Contreras-Cruz, V. Ayala-Ramirez & U. Hernandez-Belmonte. *Mobile robot path planning using artificial bee colony and evolutionary programming.* Applied Soft Computing 30(2015):319-328.

Thoughts on the paper?

Strengths:

Weaknesses:

Application to projects (if any):