DEC-TSP

Distributed Evolutionary Computing applied to the Traveling Salesman Problem

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Evolutionary Algorithms (EA)

- Natural Evolution
- EA: `simulated´ Evolution for solving computational problems
- Abstraction of biological concepts

  - Phenotype: solution to a complex problem
  - Genotype: encodes this solution
  - Fitness: a measure of solution quality
  - Mutation: random variation in the encoding
  - Selection: comparison between some phenotypes, keeping the 'winner', deleting the others
EA (2)

- Basic generational EA

```java
public void doEvolution() {
    population = generateInitialPopulation();
    while (!isEndCriterionReached()) {
        matingPool = selectToMatingPool(population);
        population = recombineAndMutate(matingPool);
        computeFitneses(population);
        nextGeneration();
    }
}
```

- Application is justified for hard problems with no conventional algorithm available
EA Framework Adaptation

- EA is Meta-heuristic
- To specify for solving a concrete problem:
  - Solution encoding
  - Genetic operators
  - Fitness function
- Suitable for parallelization:
  - Fitness evaluation
  - Application of genetic operators
DEC – Distributed Evolutionary Computing

Evolutionary Algorithm

Remote Monitor

Distributed Machine

WPDef

WPRes

Remote Node 1

Remote Node 2

Remote Node N
Traveling Salesman Problem

Problem Statement

Given:
- set of n cities,
- cost for traveling from city i to city j: c_{ij},
- defined start and endpoint

Question:
- What is the cheapest round-trip that visits each city exactly once?
- In terms of graph theory: what is the shortest Hamiltonian cycle in a complete, weighted graph?
TSP (2)

- Classification
  - TSP is an NP complete, multimodal, single-objective, combinatorial optimization problem

- Complexity
  - Example: Homer's Ulysses
    - *The Odyssey*: 16 cities \(\rightarrow\) 653,837,184,000 possible routes

- Padberg / Rinaldi Problem
  - from TSPLIB
  - 532 cities in USA
Solving TSP with DEC

- **Solution encoding**: Permutations

  ![Permutation Diagram]

- **Fitness function**
  - Euclidean length of the round-trip
  - WPDefinition: Permutation, WPResult: Tour length

- **Genetic Operators**
  - Transposition, Displacement, 2-Opt (computationally expensive)
  - Ordered Crossover, Partially Mapped Crossover
  - WPDefinition: Permutation, WPResult: Permutation
Results

- EA is robust with respect to parameter choice
  (well-known property of EAs in general)
Results (2)

- Selection pressure is means for balancing exploration and exploitation
Results (3)

- 2-opt improves results drastically
Results (4)

- Distribution is justified:
  - Computationally cheap operators, 540 evolutions, 2 machines: ~46h
  - Computationally expensive operators, 90 evolutions, 5 machines: ~18h
- As expected: overall CPU utilization depends on computation time/communication time ratio.
Thanks for your attention