A Particle Swarm Optimization Algorithm for Agent-Based Artificial Markets

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Agent-Based Model: *Bottom-up Method*

- Carry out the experiments with programmed agents
- Interactive agents with simple rules

**Motivations**

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**Initial condition**

Start

**Agents**

- Have simple rules

Choose *new strategies* with *learning algorithm*

Agents *trade* in the market

Received Profit

Report

*Economy Develops over time*

*Observed Market Equilibrium*
Motivations

Agent-Based Model
- Potential to study auctions and market mechanism designs, industrial organization topics.
- Complex problems
- Alternative to experiments & Analytical method

Algorithm complexity and robustness
- Genetic Algorithm (Arifovic 1994)
- Reinforcement Learning (Erev and Roth 1998)
Essay I: A Particle Swarm Optimization Algorithm

Particle Swarm Optimization (PSO) Algorithm

- Barnhart and Kennedy (1995)
Objectives

- Adapt particle swarm optimization (PSO) to dynamic markets
- Compare PSO & GA in Cournot market
Essay I: A Particle Swarm Optimization Algorithm

Particle Swarm Optimization (PSO) Algorithm

Select New strategy

Simultaneously

Select New strategy
Updated Strategy

\[ x_{i,k}(t+1) = x_{i,k}(t) + v_{i,k}(t) \]

\[ v_{i,k}(t+1) = w(t)v_{i,k}(t) + c_1u_1(p^l_{i,k}(t) - x_{i,k}(t)) + c_2u_2(p^g_{i,k}(t) - x_{i,k}(t)) \]

- \( w \) is an inertia weight factor
- \( c_1 \) self confidence factor
- \( c_2 \) swarm confidence factor respectively
- \( p^l_{i,k} \) local best
- \( p^g_{i,k} \) global best
Genetic Algorithm (GA)
Genetic Algorithm

- A String \( \langle a_1, a_2, \ldots, a_l \rangle \) here \( a_k \in \{0, 1\} \)
- Decode \( d_i = \sum_{k=1}^{l} a_k \cdot 2^{i-k} q_i \)

- \( \varepsilon \) elitism rate
- \( \chi \) crossover rate
- \( \mu \) mutation rate
Market Structure

Oligopsony: $M << N$

Essay I: A Particle Swarm Optimization Algorithm
Design & Method
## Results

Table I–1. PSO & GA Simulation Results with *Changing* Algorithm Parameters

<table>
<thead>
<tr>
<th>Set</th>
<th>Parameters</th>
<th>Market Price</th>
<th>Capacity Ratio</th>
<th>Machine Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Buyer 1</td>
<td>Buyer 2</td>
</tr>
<tr>
<td>PSO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0.98 2.5</td>
<td>Mean</td>
<td>80.01</td>
<td>19.99%</td>
</tr>
<tr>
<td>12</td>
<td>0.98 0.5</td>
<td>Mean</td>
<td>80.00</td>
<td>19.99%</td>
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<tr>
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<td>0.5 1</td>
<td>Mean</td>
<td>80.00</td>
<td>20.00%</td>
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<tr>
<td></td>
<td></td>
<td>SD</td>
<td>0.00</td>
<td>0.02%</td>
</tr>
<tr>
<td>14</td>
<td>0.2 1</td>
<td>Mean</td>
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<td>20.32%</td>
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<tr>
<td>GA</td>
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<tr>
<td>15</td>
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<td>81.29</td>
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<tr>
<td>16</td>
<td>20% 66% 1.00%</td>
<td>Mean</td>
<td>80.18</td>
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<tr>
<td>17</td>
<td>40% 76% 1.00%</td>
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<tr>
<td>18</td>
<td>40% 66% 0.33%</td>
<td>Mean</td>
<td>80.07</td>
<td>20.33%</td>
</tr>
</tbody>
</table>

**Theoretical Results**: *Market Price = $80; Quantity Ratio of each buyer =20%*
## Results

### Table I–2. Results under Different Algorithm Structure for PSO and GA

<table>
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<tr>
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<th>Market Price</th>
<th>Capacity Ratio</th>
<th>Machine Time</th>
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</thead>
<tbody>
<tr>
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<td>40</td>
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<td>21.32%</td>
<td>12.49%</td>
</tr>
</tbody>
</table>
Results

Market Price of PSO & GA

Quantity Strategy of GA & PSO

(a) GA  
(b) PSO
Conclusions

Agent-Based Artificial Market
- New method in AgEcon industrial organization problems

Adapt PSO to dynamic markets

PSO>GA
Thank You!