HYPANT
A Hypergame Analysis Tool

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Project Goal

To create a software tool that could

- Perform the analysis of hypergames.
- Allow users to create and store hypergames.
Game Theory

- Developed by von Neumann and Morgenstern in 1950s
- Used to mathematically study games of strategy
- Defined a game as:
  - *Players*
  - *Rules that define the players’ actions*
  - *Moves that a player can make*
- Players are considered to be rational
- Each game has one or more equilibriums
Game Analysis Algorithm

• Created by Fraser & Hipel in the 1980s
• Works on an extended game model
• Compares each player’s preferences to calculate which outcomes are stable for each player.
• Outcomes that are stable for all players are possible equilibriums for that game.
Expanded Game Definition

A Game consists of:

- **Players**
  
  *The groups or individuals involved in the conflict.*

- **Options**
  
  *The various actions that players may take. Options are either taken or not taken.*

- **Outcomes**
  
  *An outcome is a combination of all of the options, with each option either chosen or not chosen.*

- **Preferences**
  
  *Each player ranks the outcomes in their preferred order.*
Shortcomings of Games

- Games depend on perfect perception.
- Can only model situations where each player has a perfect understanding of the situation, which doesn’t always occur.
- Many disasters in the past have been caused by people having incomplete or incorrect information about their situation.
Hypergames

- Uses a number of games to model different perceptions of a situation.
- By using different games to model the conflict, conflicts where players do not have perfect perceptions can be modeled.
- Hypergames allow the modeling of strategic surprise and deception by players.
- Hypergames can model situations where players
  - Do not correctly perceive their opponents
  - Do not correctly perceive their options or those of their opponent’s
  - Incorrectly perceive the preferences of their opponent.
3rd Level Hypergame

A’s 2nd Level Hypergame

A

A’s Hypergame

AA

AAA BAA

B’s Hypergame

BA

ABA BBA

B’s 2nd Level Hypergame

B

A’s Hypergame

AB

AAB BAB

B’s Hypergame

BB

ABB BBB
HYPANT

- Hypergame Analysis Tool
- Uses Fraser and Hipel’s game analysis algorithm
- Capable of
  - Reading and writing hypergames to/from files.
  - Displaying hypergames to users.
  - Analysing individual games.
  - Analysing hypergames.
  - Writing output of analyses to screen and file.
Hypergame Modeling Language

• Need a method to describe hypergames for loading and saving them.
• A custom language allows for the use of human readable input files.
• Language can be reused in future programs.
• Easier to read in and error check than other methods.
• Games are parsed and the information put into custom datastructures, ready for analysis.
• Parser implemented with flex and bison.
HML Example

%%Cuban Missile Crisis Game
{
{
}, % Game Perception
{
{ % Player Name & Options
  USA,{{#1,Air Strike},{#2,Blockade}},{},
  { Preference Vector
    {#1=0,#2=0,#3=1,#4=0}, {#1=0,#2=1,#3=1,#4=0}, {#1=1,#2=0,#3=1,#4=0},
    {#1=1,#2=1,#3=1,#4=0}, {#1=0,#2=1,#3=0,#4=0}, {#1=1,#2=0,#3=0,#4=0},
    {#1=1,#2=1,#3=0,#4=0}, {#1=0,#2=0,#3=0,#4=0}, {#1=1,#2=1,#3=0,#4=1},
    {#1=1,#2=0,#3=0,#4=1}, {#1=0,#2=1,#3=0,#4=1}, {#1=0,#2=0,#3=0,#4=1}
  }
},
{ % Player Name & Options
  USSR,{{#3,Withdraw},{#4,Escalate}},{{#3,#4}},
  { Preference Vector
    {#1=0,#2=0,#3=0,#4=0}, {#1=0,#2=0,#3=1,#4=0}, {#1=0,#2=1,#3=1,#4=0},
    {#1=1,#2=0,#3=1,#4=0}, {#1=1,#2=1,#3=0,#4=0}, {#1=1,#2=0,#3=0,#4=0},
    {#1=1,#2=1,#3=1,#4=0}, {#1=1,#2=1,#3=0,#4=0}, {#1=1,#2=1,#3=0,#4=1},
    {#1=1,#2=0,#3=0,#4=1}, {#1=0,#2=1,#3=0,#4=1}, {#1=0,#2=0,#3=0,#4=1}
  }
}
}
}
**Screenshots**

Figure 1: Equilibriums for Cuban Missile Crisis
### Figure 2: Stability Table for Cuban Missile Crisis

#### Player: USA

<table>
<thead>
<tr>
<th>Preference Vector</th>
<th>Stability</th>
<th>UIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>#1 #2 #3 #4</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0 0 1 0</td>
<td>r</td>
</tr>
<tr>
<td>2</td>
<td>0 1 1 0</td>
<td>s</td>
</tr>
<tr>
<td>3</td>
<td>1 0 1 0</td>
<td>u</td>
</tr>
<tr>
<td>4</td>
<td>1 1 1 0</td>
<td>u</td>
</tr>
<tr>
<td>5</td>
<td>0 1 0 0</td>
<td>r</td>
</tr>
<tr>
<td>6</td>
<td>1 0 0 0</td>
<td>u</td>
</tr>
<tr>
<td>7</td>
<td>1 1 0 0</td>
<td>u</td>
</tr>
<tr>
<td>8</td>
<td>0 0 0 0</td>
<td>u</td>
</tr>
<tr>
<td>9</td>
<td>1 1 0 1</td>
<td>r</td>
</tr>
<tr>
<td>10</td>
<td>1 0 0 1</td>
<td>u</td>
</tr>
<tr>
<td>11</td>
<td>0 1 0 1</td>
<td>u</td>
</tr>
<tr>
<td>12</td>
<td>0 0 0 1</td>
<td>u</td>
</tr>
</tbody>
</table>

#### Player: USSR

<table>
<thead>
<tr>
<th>Preference Vector</th>
<th>Stability</th>
<th>UIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>#1 #2 #3 #4</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0 0 0 0</td>
<td>r</td>
</tr>
<tr>
<td>2</td>
<td>0 0 1 0</td>
<td>s</td>
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<tr>
<td>3</td>
<td>0 1 1 0</td>
<td>r</td>
</tr>
<tr>
<td>4</td>
<td>0 1 0 0</td>
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<td>5</td>
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<tr>
<td>9</td>
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<td>10</td>
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<td>11</td>
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<td>u</td>
</tr>
<tr>
<td>12</td>
<td>0 0 0 1</td>
<td>u</td>
</tr>
</tbody>
</table>
>>>-- 2nd level Hypergame results --<<<<
Overall Hypergame
Equilibrium(s)

Equilibrium #1:
France Options
  + Move North
Germany Options
  + Attack Through Ardennes

Equilibrium #2:
France Options
  + Defend Maginot Line
Germany Options
  + Attack Through Ardennes

>>>-- 1st level Hypergame results --<<<<
Hypergame is for France's game
Equilibrium(s)

Equilibrium #1:
France Options
  + Move North
Germany Options
  + Attack In The North

Hypergame is for Germany's game
Equilibrium(s)

Equilibrium #1:
France Options
  + Move North
Germany Options
  + Attack Through Ardennes

Equilibrium #2:
France Options
  + Defend Maginot Line
Germany Options
  + Attack Through Ardennes
Testing

Two different methods of testing were used on the analysis component of the program.

- Convert previously analysed games into HML and analyse with HYPANT.
  - Compare the output with those previously calculated.
- Alter existing models to create "What If" games.
  - Analyse altered games and see if the output seems sensible, given the input.
Program Limitations

- Hypergame models must be written in HML by a person in order to analyse them.
Future Research

• Extend parser with error recovery & sanity checking on input.
• Extend tool to allow creation of hypergames.
• Applying hypergames to Artificial Life simulations.
Questions?