Linguistic Geometry: Adversarial Reasoning for Real Life Problems

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What is Linguistic Geometry?
Claude Shannon
A Comparison of Searches for the same processing time

- Brute Force Search
- Alpha-Beta Search
- Human Expert Search and LG Search
### 1997

#### Rematch

**Garry Kasparov**

**vs**

**Deep Blue**

<table>
<thead>
<tr>
<th>Facts</th>
<th>Garry Kasparov</th>
<th>IBM's Deep Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height:</td>
<td>5'10&quot;</td>
<td>6'5&quot;</td>
</tr>
<tr>
<td>Weight:</td>
<td>176 lbs.</td>
<td>1.4 tons</td>
</tr>
<tr>
<td>Age:</td>
<td>34 years</td>
<td>4 years</td>
</tr>
<tr>
<td>Birthplace:</td>
<td>Azerbaijan</td>
<td>Yorktown, NY</td>
</tr>
<tr>
<td># Processors:</td>
<td>100B Neurons</td>
<td>32 P2SC Processors</td>
</tr>
<tr>
<td>Moves/Second:</td>
<td>2</td>
<td>200 million</td>
</tr>
<tr>
<td>Power Source:</td>
<td>electrical/chemical</td>
<td>electrical</td>
</tr>
<tr>
<td>Next Career:</td>
<td>champion</td>
<td>none</td>
</tr>
</tbody>
</table>
Mikhail Botvinnik

1911 - 1995
6th World Champion
Mikhail Botvinnik
"To Achieve the Goal"
A Flow Chart of The Algorithm for Playing Chess
There have been a few challenges to the “Botvinnik Computer Problem.” Typical of these challenges is the letter from Thomas Chasseur, 1345 53rd Ave., Oakland, CA 94601. “I think your magazine is of great interest,” writes Tom. “And I enjoy reading it, not only for enjoyment but as a supplement to my college education with a major in Data Processing and a minor in Math. I have been playing chess for over 20 years and I am astounded by the solution given to the Botvinnik End Game, as solved by his PIONEER program!” (See the diagram for original position.)
The computer chooses the move that forces the opponent to get the least score. In this example, the best Black can do, if White chooses Pg5-g6 is a score of 3. In this case this score is a win for White.

The numbers shown here are scores computed by Pioneer. Positive numbers are good positions for White. Negative numbers are good positions for Black.

Most likely path is indicated by double line assuming Black makes best move. Both paths lead to a score of 3 with White gaining a Queen. Actual moves would probably follow the upper path.

o = White Node
• = Black Node
| = End of Variation

First Winning Strategies
First Strategies with Positional Sacrifices

Moscow, USSR
Program
PIONEER
Types of Zones

- Attack
- Block or Relocation
- Domination
- Retreat
- Unblock

Zones
An Abstract Board Game is the following eight-tuple

\[ < X, P, R_p, \{ON\}, v, S_i, S_t, TR> \]

- \( X = \{x_i\} \) is a finite set of points;
- \( P = \{p_i\} \) is a finite set of elements; \( P = P_1 \cup P_2, P_1 \cap P_2 = \{\} \);
- \( R_p(x, y) \) is a family of binary relations of reachability in \( X \) \( (x \in X, y \in Y, p \in P) \); \( y \) is reachable from \( x \) for \( p \);
- \( ON(p) = x \) is a partial function of placement of elements \( P \) into \( X \);
- \( v > 0 \) is a real function, \( v(p_i) \) are the values of elements;
- \( S_i \) is a set of initial states of the system, a certain set of formulas \{ON(p_i)=x_i\};
- \( S_t \) is a set target states of the system (as \( S_i \));
- \( TR \) is a set of operators \( TRANSITION(p, x, y) \) for transition of the system from one state to another described as follows
  - **precondition**: \( (ON(p) = x) \land R_p(x, y) \)
  - **delete**: \( ON(p) = x \)
  - **add**: \( ON(p) = y \)
First Hierarchy of Languages, a predecessor of LG
\[ Z = t(p_0, a(1)a(2)a(3)a(4)a(5), 5)t(q_3, a(6)a(7)a(4), 4) \\
  t(q_2, a(8)a(9)a(4), 4)t(p_1, a(13)a(9), 3) \\
  t(q_1, a(11)a(12)a(9), 3)t(p_2, a(10)a(12), 2) \]
The Arts Building is framed by fall leaves.

1990-91
McGill University
From 2D to 3D Models

First 3D Board
From Limited to $n \times n$ Variable Size District

First $n \times n$ Board

1995
First Concurrent Strategies
Experiments with State Space Chart:
NO-Search Approach

Start State

WB-Intercept and BB-Protect

WB-Protect and BB-Protect

WB-Intercept and BB-Intercept

White Wins

Black Wins

DRAW

DRAW

First Proof of Strategies Optimality

1996
Planning of Maintenance Planning of Power Units

First Artificial Enemy in LG

1997
Computational complexity of the specific classes of abstract board games is polynomial with respect to the length of the input.
• Linguistic Geometry (LG) is a new type of game theory;

• LG replaces search by construction, making the games computationally tractable.
DARPA JFACC Experiments 1999 – 2001

Validation of SEAD Strategies: Expert Opinions
Validation of MOUT Strategies: Competition with People
What is Linguistic Geometry?

- Chess Masters’ Problem Solving
- Search Reduction Techniques
- Subclass of Gaming Problems of Polynomial Complexity
- No-Search Paradigm for Decision Making: “From Search to Construction”
- OR maybe, it is something else . . .
It appears that LG is a model of human thinking about conflict resolution, a warfighting model at the level of superintelligence . . .