Seki and Graphs

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Outline

Introduction

Equivalence of Positions

Basic Seki

Generating All Basic Seki

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More than 2 Liberties per Chain

Local and Global Seki

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Definition and Examples of Seki

Seki (Japanese) = mutual life
Definition and Examples of Seki

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Sensei’s Library:

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Hanezeki
Motivation: Before playing a game one should know when to stop, i.e. when is a position a seki. Studies of semeai and also scoring algorithms need to know about how to recognize seki.
Aim of Talk

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*Aim:* Finding a subclass of seki that allows to classify and generate all seki of this class.
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- introduction of cuts
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Non-terminal Positions

We are only interested in terminal positions.

Non-terminal seki

Terminal seki
Shift and Deformation

All of these positions are equivalent.
Introducing Cross Cuts I

Also all of these seki are essentially identical despite two having a cross cut.
Introducing Cross Cuts II

The following positions differ even more but are still equivalent.
What is the essence of a seki position?
Commonly used in Go: the *Common Fate Graph* (CFG):

Circles: red: white chain, blue: black chain, black: liberty
Lines: neighbourhood relations

Figure: The corresponding CFG
Common Fate Graphs

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But this graph still contains irrelevant information.
The same types of seki on previous slide have different CFG.
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But this graph still contains irrelevant information.
The same types of seki on previous slide have different CFG.
→ We need a more compact graph.
But the choice of graph depends on the type of seki to be considered.
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The Class of Basic Seki

Let us consider what will be called 'Basic Seki':

All chains are essential and have 2 liberties (+ possibly additional chains of 1 or 2 stones with only 1 liberty in an opponent eye). Positions are terminal, i.e. a move taking an opponent liberty gets instantly captured.
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Basic Seki Graphs

This special class of seki allows more compact graphs: *Basic Seki Graphs* (BSG). Example:

![Graph](image)

Figure: The 2 corresponding graphs: CFG and BSG
Properties of Basic Seki Graphs I

Necessary properties for graphs to represent basic seki:

- Edges are coloured (white/black chain → red/blue edge)
- Each node (i.e. liberty) has at least one and at most four edges (i.e. neighbouring chains).
- There has to be at least one red and one blue edge (otherwise life, not seki).
- If two edges of same colour, say red, end in a shared node, say \( M \), then both red edges must have their other end in the same other node, say \( N \) (otherwise White can move on \( M \) and give atari without being captured).
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Figure: Two forbidden and two admissible graphs
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If two nodes are linked to each other by edges of different colour then these two nodes are all the nodes of the graph (consequence of previous statement, rightmost figure).
Properties of Basic Seki Graphs I

- If two nodes are linked to each other by edges of different colour then these two nodes are all the nodes of the graph (consequence of previous statement, rightmost figure).
- If a node has edges of only one colour then these edges may reach only two other nodes (otherwise a move on $M$ creates a chain with 3 liberties).

Figure: A forbidden and an admissible graph
Main conclusions:

- *Edges originating from one node can reach at most two other nodes!*
Summary on Basic Seki

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- *Therefore Basic Seki consist either of a linear or a circular sequence of liberties where two neighbouring liberties are connected by only chains of one colour.*
Main conclusions:

▶ Edges originating from one node can reach at most two other nodes!
▶ Therefore Basic Seki consist either of a linear or a circular sequence of liberties where two neighbouring liberties are connected by only chains of one colour.
▶ The case of only 2 liberties connected by black and white chains can be seen as the smallest circular sequence.
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A Numerical Encoding

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A Numerical Encoding

Basic Seki are linear or circular (i.e. 1-dimensional)
⇒ possibility to encode any Basic Seki through a (linear) sequence of symbols, e.g. numbers.

It turns out that conditions on Basic Seki Graphs shown before are not only necessary but also sufficient.
⇒ Generating all sequences of such number encodings will generate all Basic Seki.
The Translation Rules

The following rules allow a literal translation of Basic Seki Graphs into a sequence of numbers:

- Linear seki (2 nodes have each only 1 neighbouring node) → start with a 0
- Circular seki: (each node has 2 neighbouring nodes) → do not start with a 0 (i.e. no 0 at all)
- Abbreviation: for example 12 = (12) \( ^3 \)
- Two seki attached on board to one seki → ... + ...
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The following rules allow a literal translation of Basic Seki Graphs into a sequence of numbers:

- $0 = \circ$
- $1 = -
- $2 = \bigcirc$
- $3 = \bigcirc$

Figure: Abbreviations of graph elements by digits
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- 0 = \(\text{node}\)
- 1 = \(\text{single line}\)
- 2 = \(\text{loop}\)
- 3 = \(\text{double loop}\)

\[
\begin{align*}
0 &= \text{node} & 1 &= \text{single line} & 2 &= \text{loop} & 3 &= \text{double loop} \\
1 &= \text{dotted line} & 2 &= \text{dotted loop} & 3 &= \text{dotted double loop}
\end{align*}
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**Figure:** Abbreviations of graph elements by digits

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- **two seki attached on board to one seki** → ... + ...

**Figure**: Abbreviations of graph elements by digits
Examples of linear Seki I

encoding: 012
Examples of linear Seki II

encoding: 022
Examples of linear Seki III

"The Scream" with encoding: 0121
Examples of linear Seki IV

"The Onion" with encoding: 0111111111 = 01(11)^4
looks circular but is linear.
Examples of circular Seki I

encoding: _11_
Examples of circular Seki II

encoding: 31
Examples of circular Seki III

encoding: $1111 = (11)^2$
Generating all Basic Seki

To generate all topological types of Basic Seki:

- start with a 0 to encode a seki with linear topology,
- having apart from the optional initial 0 an arbitrary sequence of digits 1,1, 2,2, 3,3 except have at least one underlined and one not underlined digit,
- the sum of any two neighbouring digits \(\leq 4\) and for circular seki first + last digit \(\leq 4\)
- avoid identical linear basic seki (inversion, colour switch, e.g. 021 = 0112 = 0211)
- avoid identical circular basic seki (inversion, colour switch, cyclic permutation, e.g. 21 = 12 = 121 = ...)
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Attaching Seki

A full board seki of G. Hungerink

The BSG of the whole board consists of three disconnected sub graphs and has the encoding

\[ 1211 + 0(22)^41(22)^61211(22)^61211(22)^61(22)^4 + 1121. \]
Cutting off a Stone I

Figure: The change of BSG

Encoding: 111  encoding: 111  encoding: 211
Cutting off a Stone II

encoding: 11

encoding: 21

encoding: 011

encoding: 021
Creating an Eye I

Figure: The change of CFG
Creating an Eye II

encoding: _11

encoding: _111

encoding: _111

encoding: _1111
Bamboo Joints in Basic Seki I

encoding: 21

encoding: 22

encoding 21

encoding: 22
Both seki have the encoding 22 but different sequences of black and white stones around liberties (WBWB and WWBB).
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A theory of seki between chains
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- with more than 2 liberties,
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- where each liberty has exactly one white and one black neighbouring chain.
Work of Vladimir Gurvich I

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A position with $m$ white chains and $n$ black chains is encoded as an $m \times n$ matrix $A$ with only non-negative entries $A_{ij}$ that give the number of liberties between the white chain $i$ and the black chain $j$. 

\[
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Problem: For a given computer determined seki matrix a Go position may not exist, e.g. not for: $$
\begin{pmatrix}
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1 & 1 & 1 \\
\end{pmatrix}.
$$
Lemma: (giving sufficient conditions for Black to capture)  
Even when playing second, Black captures if there is a row $i$ such that $s^B_j - A_{ij} \geq s_i^W$ for every column $j$ and $s_j^B > s_i^W$ if $A_{ij} = 0$. 

Table: The liberty matrix
Seki with > 2 Liberties per Chain

We need new graphs where
- edges represent liberties and
- nodes represent chains
(because now only 2 chains per liberty but > 2 liberties per chain).
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⇒ graph needs to be planar (i.e. it must be possible to draw graph on paper without crossing edges)
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Further, on a Go board stones do not lie on top of each other ⇒ graph needs to be planar (i.e. it must be possible to draw graph on paper without crossing edges)
⇒ We are looking for bi-partite planar graphs!
Bi-partite planar 3-regular Graphs

Sensei’s Library [4]:

Figure: The corresponding Graph
Bi-partite planar 3-regular Graphs

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Figure: The same Graph
Planar Graphs and their Dual

Figure: A planar Graph
Planar Graphs and their Dual

Figure: A planar Graph

Figure: with it’s dual Graph
The Cube and the Octagon

Figure: The dual Graph of a Cube
The Cube and the Octagon

**Figure:** The dual Graph of a Cube

**Figure:** is an Octagon
Figure: This replacement of any edge generates each time a new graph and thus a new seki.
The position resulting from the complication step.
Higher regular Graphs

How about seki of this type with chains having each 4 or more liberties?

One can prove:

There are no simple bi-partite planar graphs that are 4- or higher regular (Kathie Cameron).

In other words, there are no seki with chains having each the same number of 4 or more liberties but only 1 shared liberty between any 2 chains.

But, bi-partite planar 3-regular graphs are perfect matchings. ⇒ opportunity to generate higher regular graphs with multi-edges. (i.e. seki with pairs of chains sharing more than 1 liberty).
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Again a bi-partite planar 3-regular Graph

Figure: A cubical graph
A bi-partite planar 4-regular Graph

Figure: A cubical graph
A bi-partite planar 5-regular Graph

Figure: A cubical graph
A bi-partite planar 6-regular Graph

Figure: A cubical graph
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‘Local Seki’ versus ‘global Seki’

⇒ Each attacking chain is captured (i.e. is a local seki) but in return an opponent chain can be captured (i.e. no global seki).
⇒ Sacrifice a small chain and catch a big one
⇒ no “real” seki.
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Figure: Global instability of Cubical Seki

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‘Local Seki’ versus ‘global Seki’

Figure: Global instability of Cubical Seki

⇒ Each attacking chain is captured (i.e. is a local seki) but in return an opponent chain can be captured (i.e. no global seki).
⇒ Sacrifice a small chain and catch a big one ⇒ no “real” seki.
A Sacrifice in a Local Seki

Black to play and sacrifice a small chain to catch a bigger one.
A Sacrifice in a Local Seki

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The End

Thank you!