BGS 2019

Teaching and Learning with Ludii

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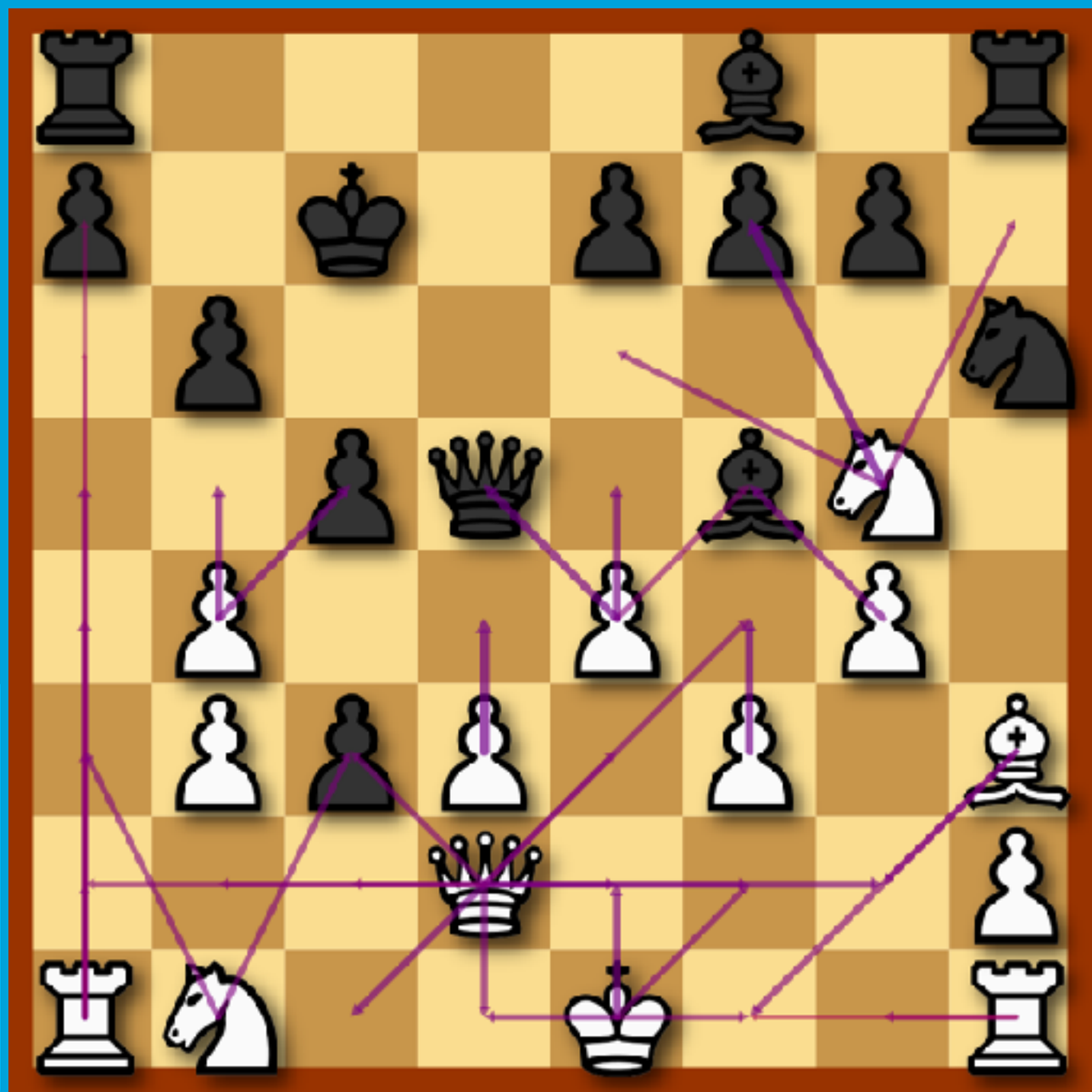

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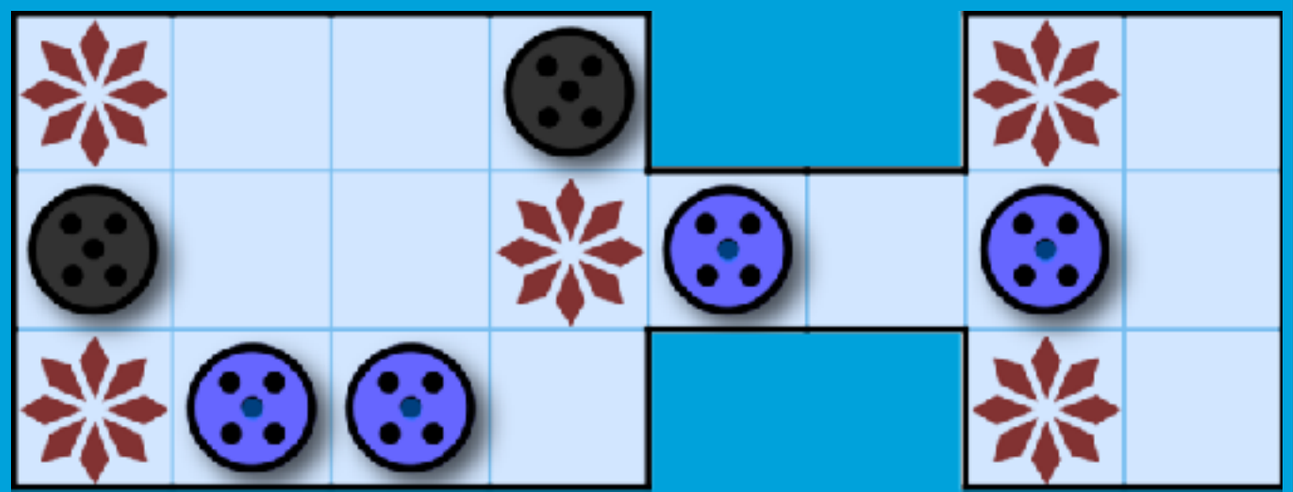
Digital Ludeme Project



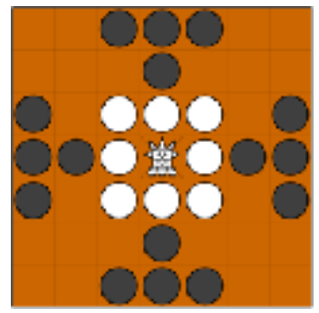
LUDII

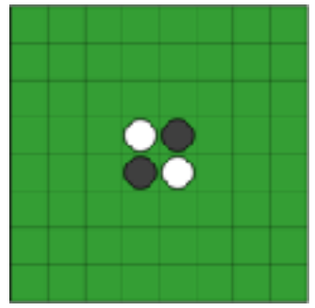
LUDII general game system for:

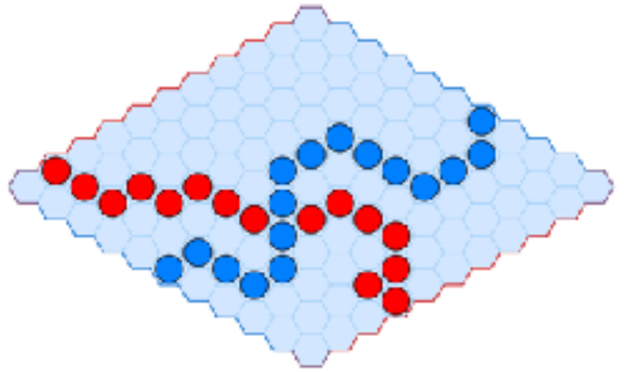
- Modelling
- Playing
- Evaluating
- Optimising
- Generating

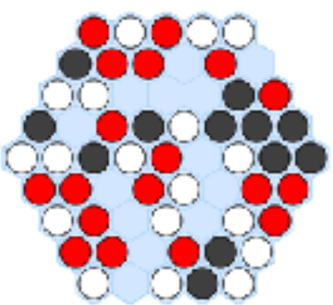
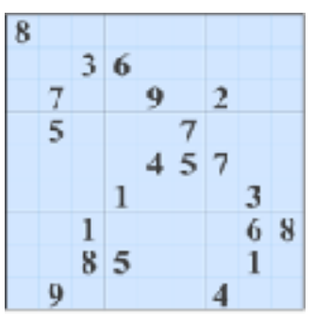
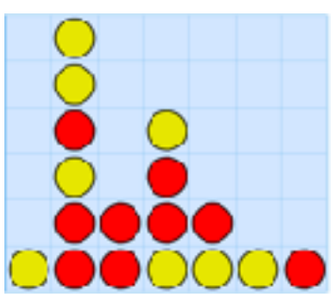
Describe a large assortment of strategy games across many different cultures and time periods.

Games described in a simple and clear manner, with easily adjustable properties.







Ludemes

- Game “memes”:
  - Units of game-related information
  - Building blocks (DNA) of games
- Encapsulate key concepts

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e.g.

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(size 3 3)
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(board
  (tiling square)
  (shape square)
  (size 3 3)
)
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(board
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  (shape square)
  (size 3 3)
)
```

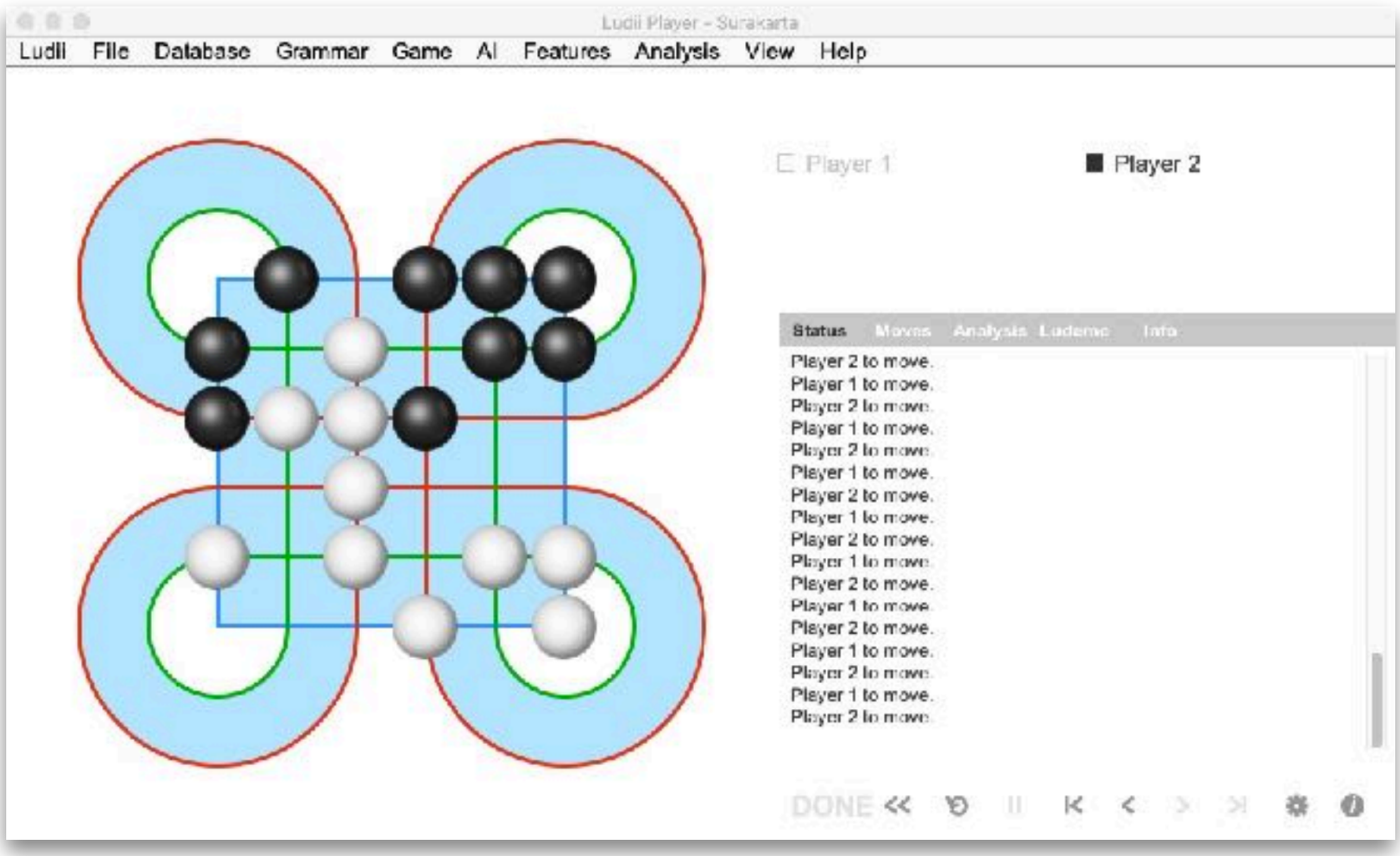
```
(game Tic-Tac-Toe
  (players White Black)
  (board
    (tiling square)
    (shape square)
    (size 3 3)
  )
  (move (add Own Empty))
  (end (All win (in-a-row 3)))
)
```

Benefits

- **Simple:** Define new games in minutes/seconds
- **Powerful:** Only approach to model full range of games
- **Compact:** Small file sizes (QR codes)
- **Comprehensible:** Human-readable
- **Efficient:** Our ludemic Chess is 10,000x faster than GGP
- **Convenient:** Easy to manipulate and evolve
- **Granular:** Break games down, label with math. keywords

Visual Style

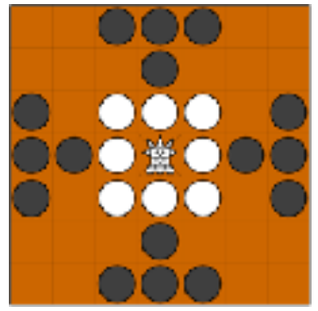
- Clean, abstract, informative, but attractive
- Emphasis on usability and ease of analysis

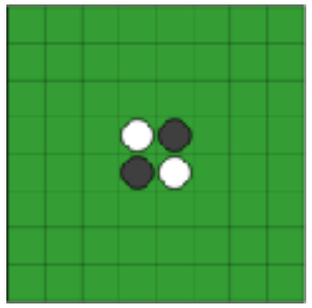


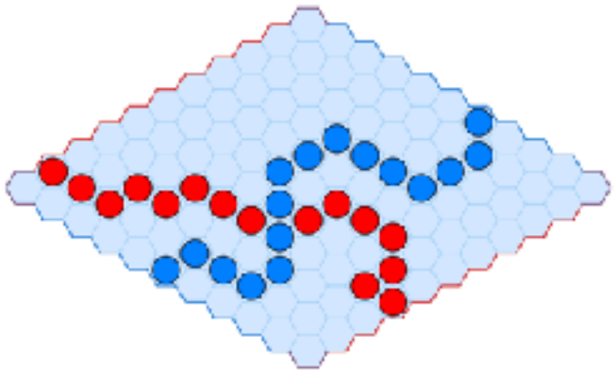
First Public Release of LUDII on August

http://www.ludii.games

Teaching and Learning



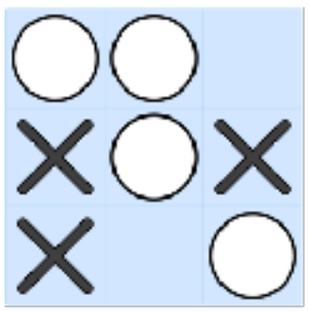


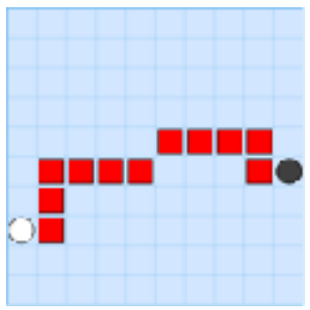


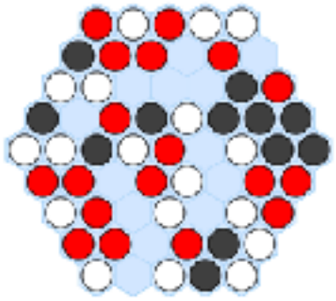
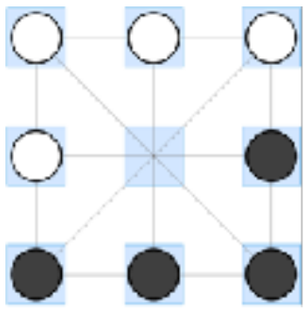
Educate students about:

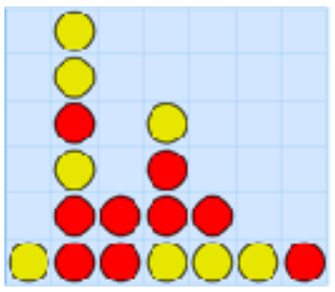
- Game design principles
- AI techniques
- Mathematical concepts
- History and culture of board games

Interactive tool in lectures or classrooms.





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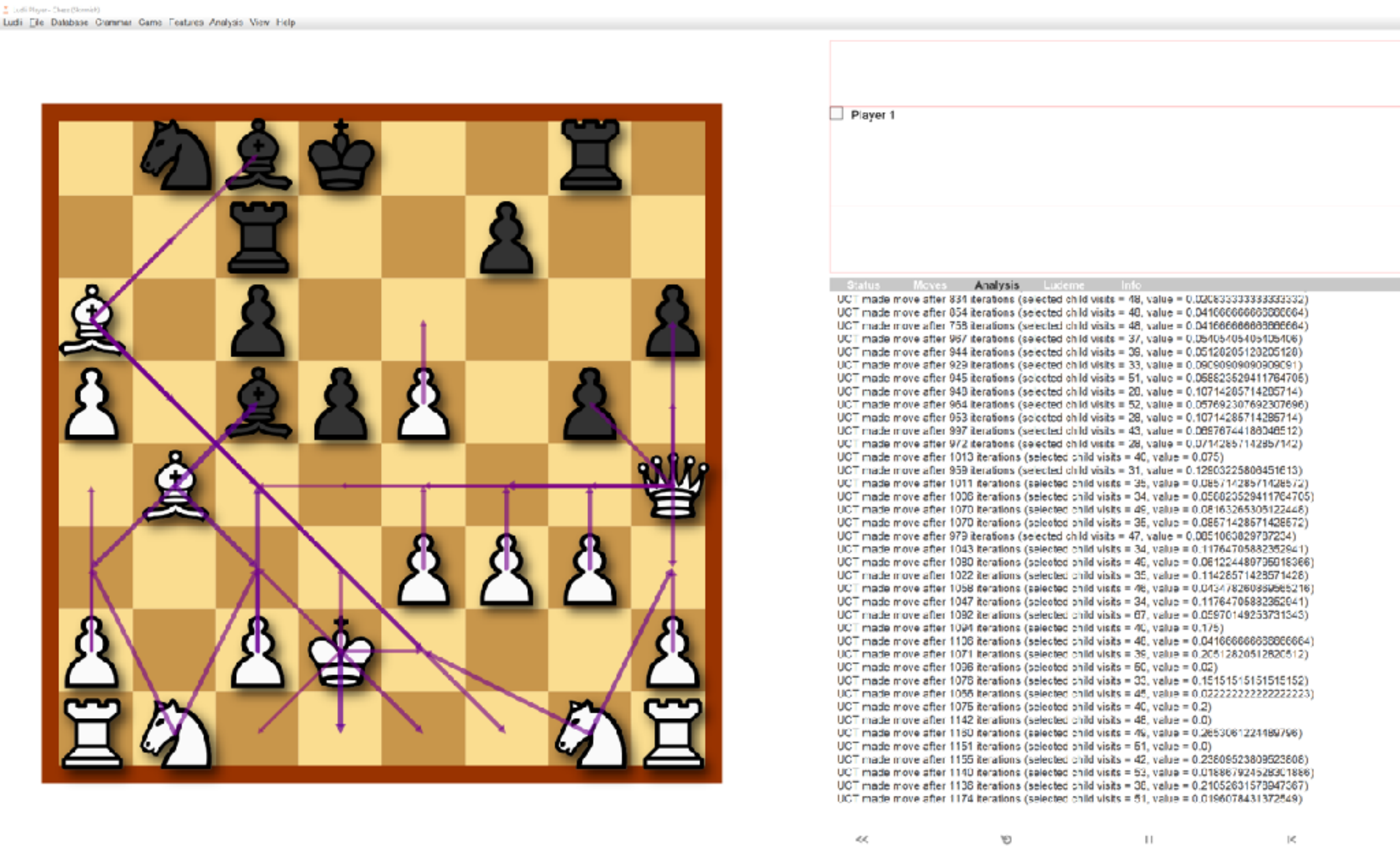
Game Analysis using AI

- AI can often identify flaws and weaknesses in games much easier and faster than humans can.
- Help us to understand good game design principles.
- Evaluate games in terms of different quality metrics:
  - Fairness / Biases
  - Strategic Depth
  - Rules Complexity
  - Game Length
  - Drawishness

Game Analysis using AI



Transcription Errors

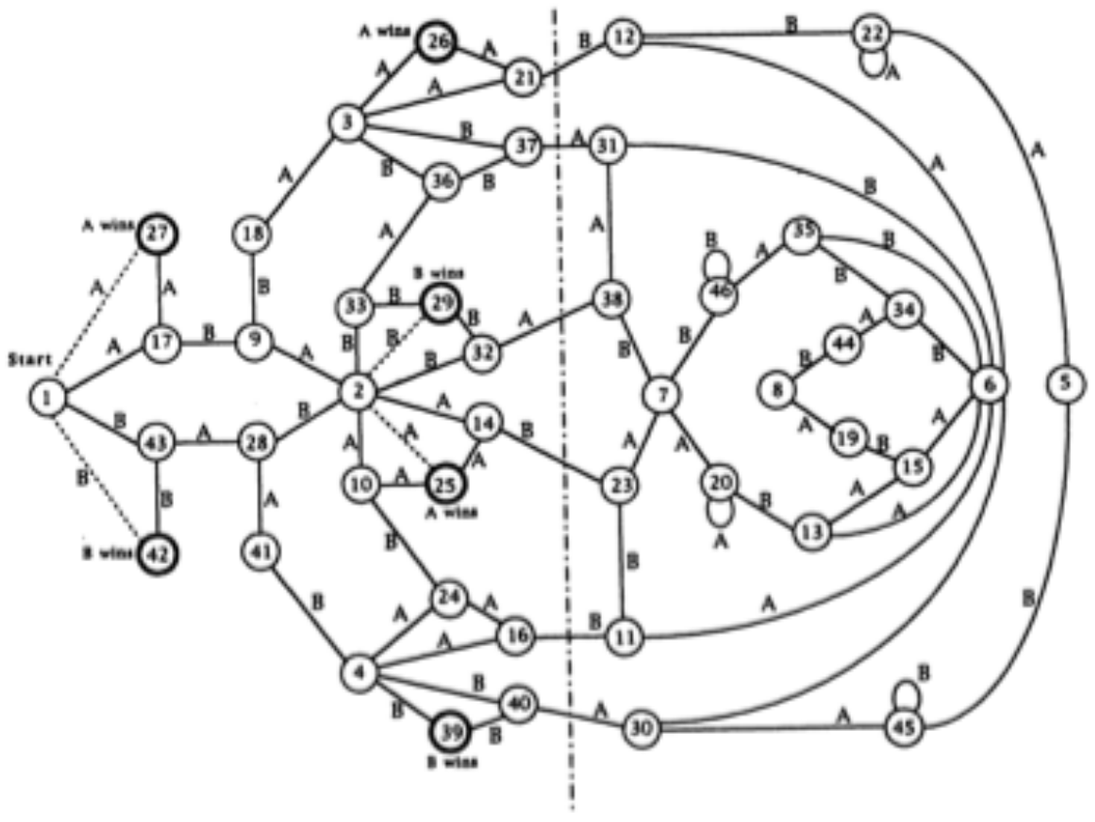
Mu Torere

- Maori, New Zealand, 18thC
- Key rule: *Can only move to centre if adjacent to enemy piece*

Ascher (1987) survey

- Two historical accounts omit this rule
- Game ends after 1 move
- Not how it is played

- Simplest analysis would have revealed this



Translation Errors

Hnefatafl
- Scandiavia, c.400BC
- No rules found

Linnaeus (1732)
- Saw Tablut played
- Recorded in travel diary (in Latin)

Smith (1811)
- Translated into English

Murray (1913) *History of Chess*
- Published rules, became de facto

Translation Errors

BUT...

Smith's translation had a critical error:

- "…likewise the king…"

not

- "…except the king…"

King almost impossible to capture:

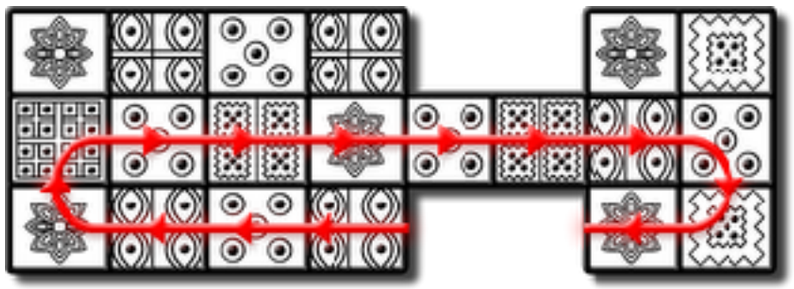
- King's side always wins
- Biased game, corrected ever since
- **Not how it was played**

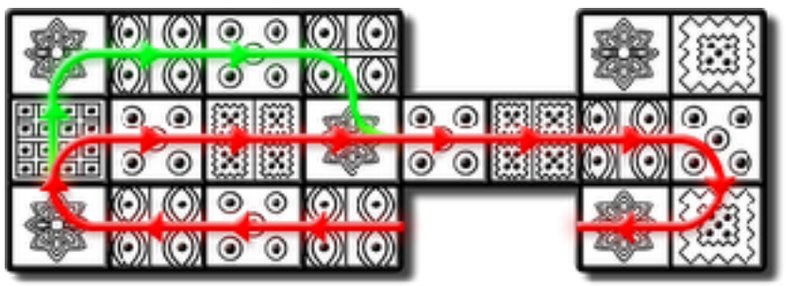
Royal Game of UR

- Mesopotamia, 2600BC

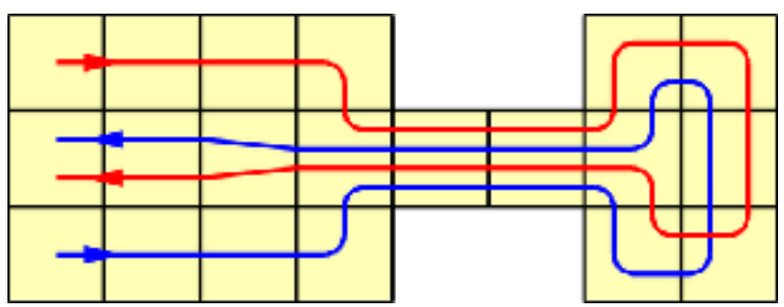
Oldest recorded rules:

- Found by Finkel (1990)
- Lucky find!
- Losing game evidence all the time





- Royal Game of Ur:
  - Which track?



Example exercise for teaching

Poprad Game (Slovakia)
- Tomb dated to 375AD
- Germanic chieftain

Board:
- 17x15/16 grid

Pieces:
- 2 x Colours
- 1 or 2 x Sizes?

Task students to identify a strategically deep and balanced set of game rules that involve these components.

Visualising AI techniques

- Many different algorithms and AI techniques exist for playing games.

- Monte Carlo Tree Search (MCTS)
- Upper Confidence Bound (UCT)

$$A_t = \begin{cases} \operatorname{argmax}_i \left(\hat{\mu}_i(t-1) + \sqrt{\frac{2 \log f(t)}{T_i(t-1)}} \right), & \text{if } t > K; \\ t, & \text{otherwise.} \end{cases}$$

- Rolling Horizon Evolution

$$a^* = \underset{a \in A(s)}{\arg\max} \left\{ Q(s,a) + C \sqrt{\frac{\ln N(s)}{N(s,a)}} \right\}$$

- StockFish (Chess)
- AlphaZero (Go, Shogi, many others)

- Difficult to visualise how exactly these algorithms think.

Visualising AI techniques

- Ludii allows us to visualise how these algorithms perform for any game.
  - How much an AI is thinking about a move.
  - How good or bad the AI thinks a move is.
  - How confident the AI is that it can win.

- Identify limitations in our AI techniques.

- AI can help identify new game strategies not previously considered by humans.

- Demo!

Games and Mathematics

Tagging ludemes with underlying mathematical concepts:

- Geometry
- Logic
- Algebra
- Arithmetic
- Etc.

Identify which games can help teachers to demonstrate different mathematical ideas to students.

Rithmomachia (11thC)

History and Culture

- Games are an important part of many cultures and have a long history.

- Another aspect of Ludii will involve recording historical and cultural evidence for each game.

- Can provide many tools for teaching the history of games.

GeoCron

Geo-temporal database

Yearly maps:

- 3,000BC—today
- 2,000 civilisations

GeoCron: Viking route from Norway to Paris (845AD)

Provide GPS+date:

- Culture/civilisation
- Country/nation/state
- Political boundaries
- Historical sites/events
- Trade/exploration routes

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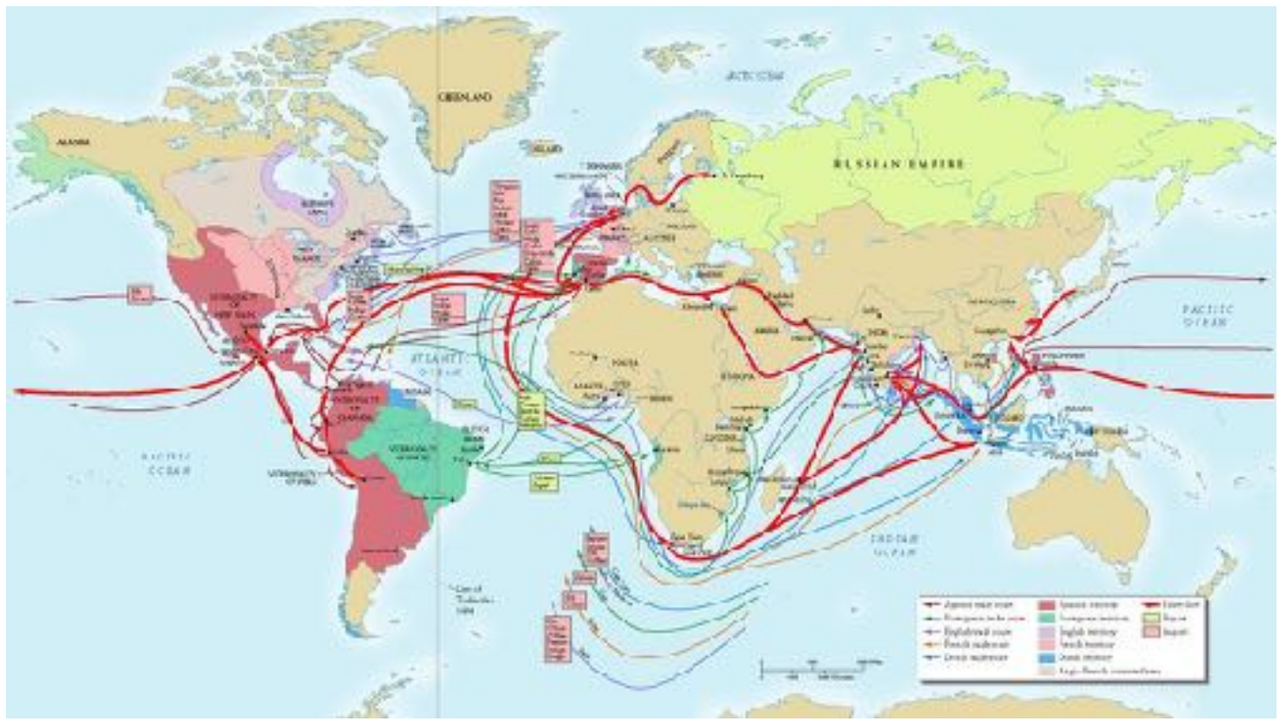
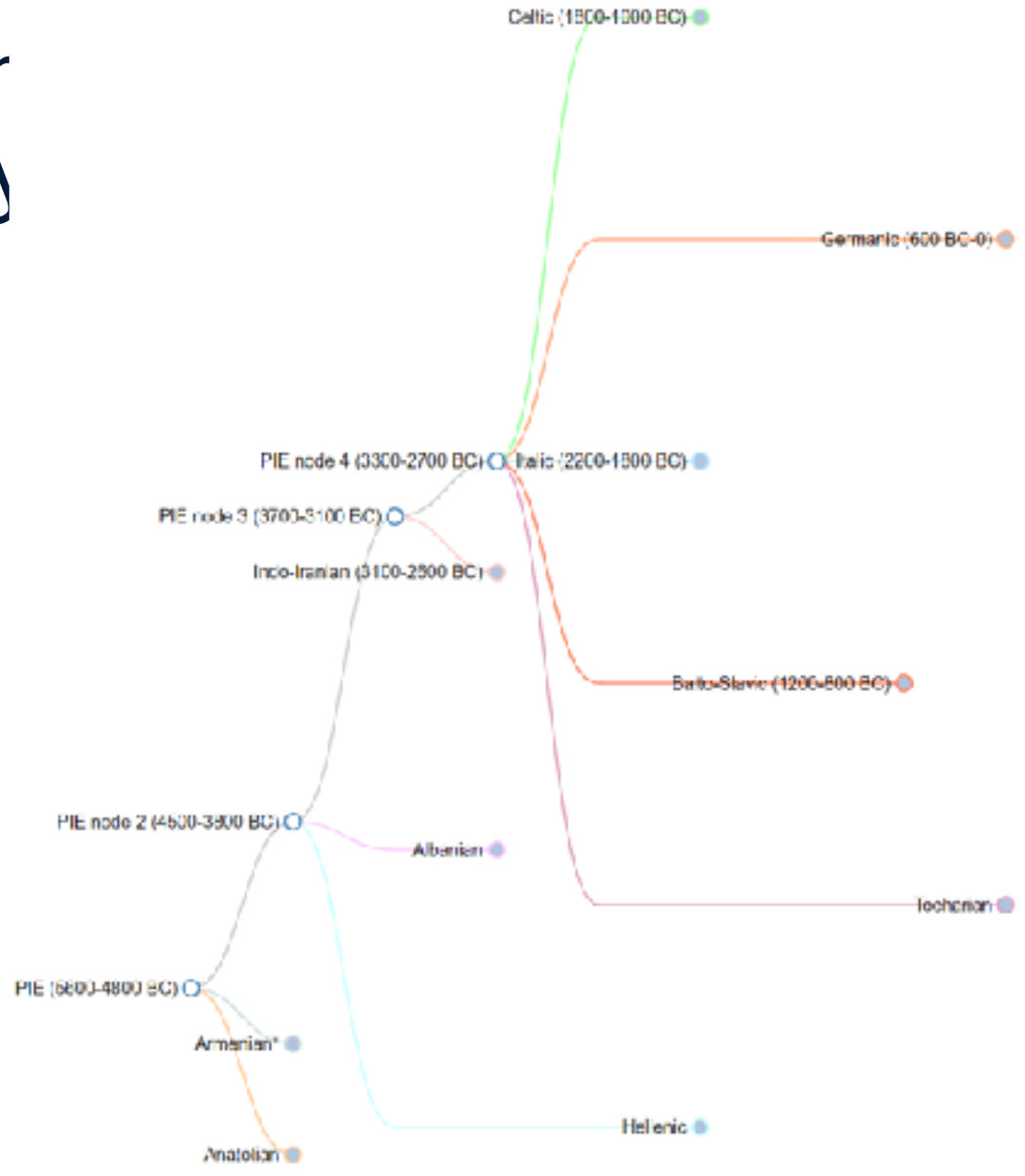
Visualising the History and Spread of Games

- Use an interactive map to represent the spread of games and ludemes across time and place.
- Possible to trace individual gar
  or ludemes throughout history
  (family tree or network).





Conclusion

Digital Ludeme Project

http://www.ludeme.eu

Thank You!

First Release of LUDII on August

http://www.ludii.games

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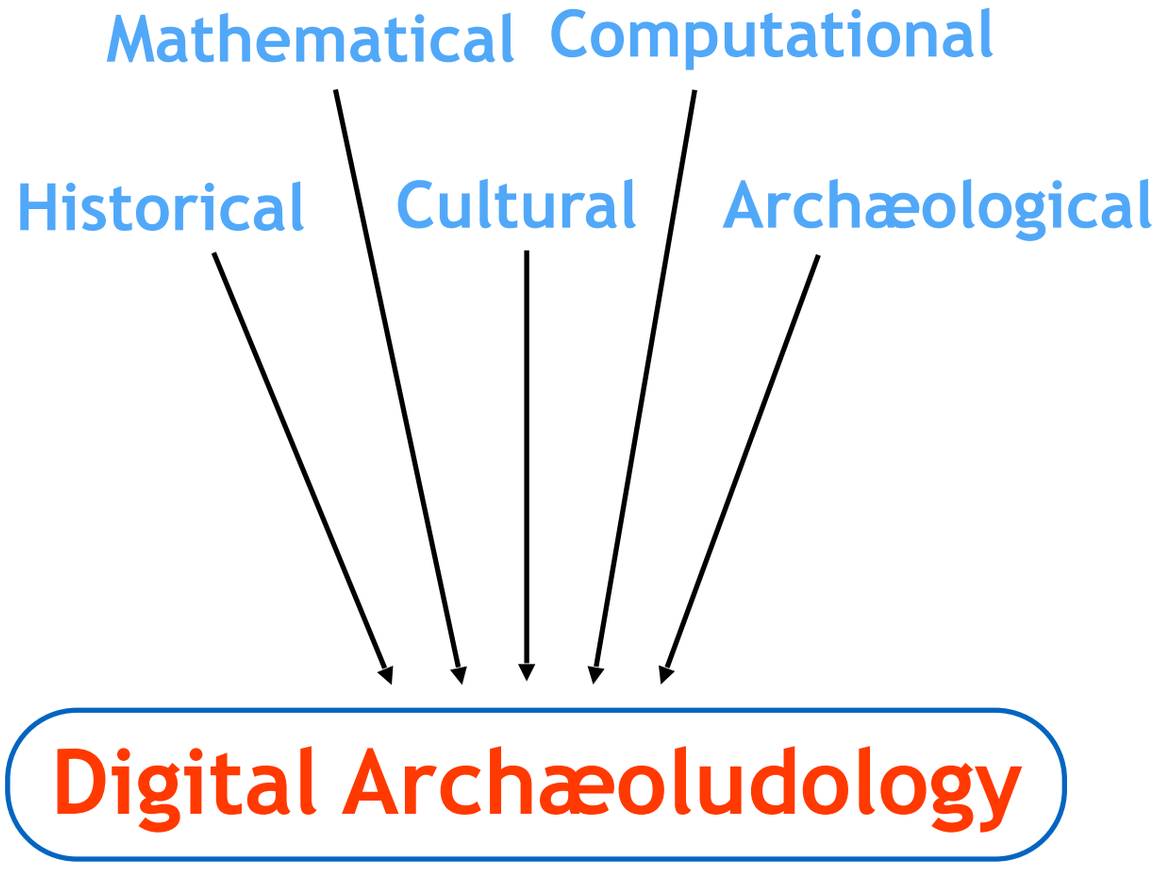
Go
China, 548BC
(Japanese players)

Digital Archæoludology

Digital Archæoludogy:

- New field of research
- Several research strands
- Single unified approach



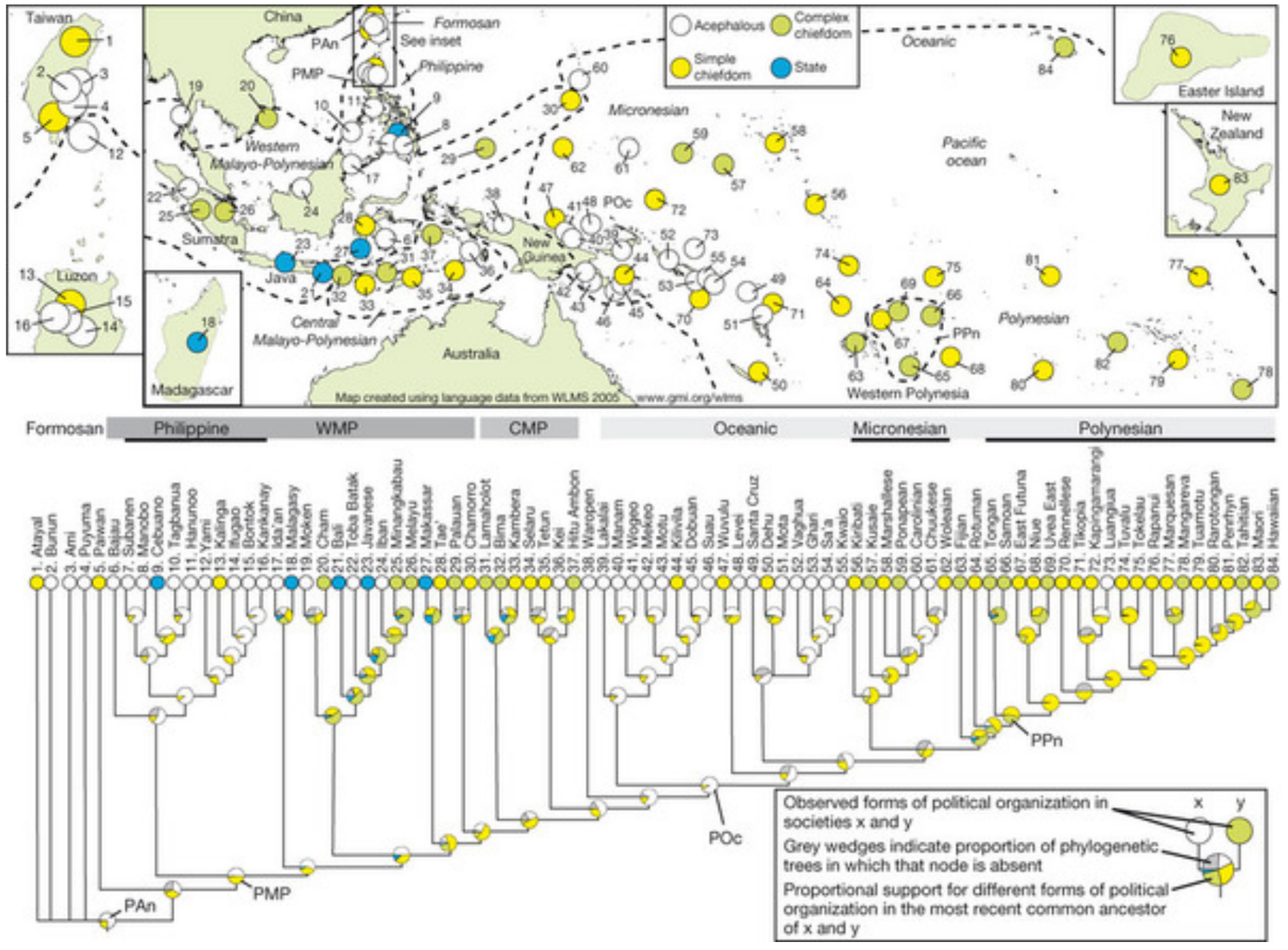
Modern comput. techniques:

- Analysis and reconstruction
- Incomplete descriptions

Computational Phylogenetics

"Family tree" of traditional games

- Principles similar to linguistics
- Ancestral state reconstruction
- Missing links?



Phlyogenetic analysis of Austronesian societies
Currie (2010) *Nature*