### Knowledge Discovery in Awari Endgame Databases

695 Data Mining Project Anita Petrinjak and Darse Billings

#### Introduction: Awari

Awari – ancient African game



#### Introduction: Awari

- 4000 year old pit and pebble game
- Computers play Awari much better than humans
- Very fast search (Mpps, Bppm, 27-ply)
- Evaluation function is still very crude

# Introduction: Awari



# Softwari

Roel van der Goot
Applet: web.cs.ualberta.ca/~games/

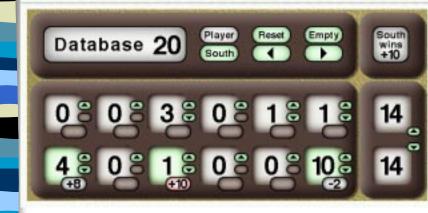


U of A wins the silver medal in London

# Awari Endgame Databases

- Endgame databases are BIG (Chinook)
- Awari endgame DBs are **REALLY BIG**
- Provides an <u>oracle</u> of perfect knowledge, but nothing explicit about *general strategy*

# Endgame Database



Thomas Lincke's Endgame Applet

# Knowledge Discovery

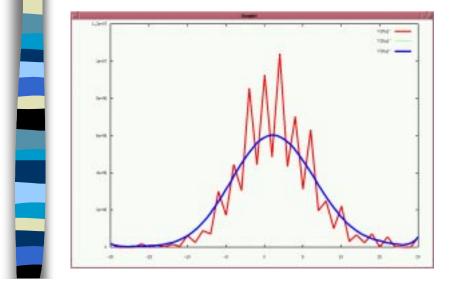
- Encorporating human knowledge in a game playing program is always tough, but we don't even have good domain knowledge for Awari
- Project Goals:
  - extract knowledge that can be used to construct a good evaluation function
  - add to human knowledge about Awari



### Methods of Analysis

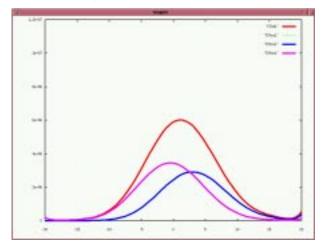
- A *feature* is a property (*eg.* balance) *Atomic feature*: pit *i* has *j* pebbles
- Association rule mining, where each position is a "basket" of 12 items
- We have all possible transactions with weights (*cf.* Negative assoc. rules)
- Tally all values → expected value (EV)

## Frequency of database values



#### Non-capture and capture positions

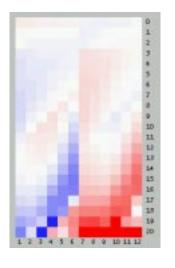
- data filtering

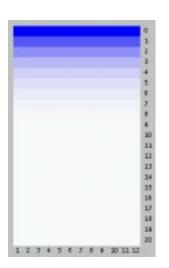


	Re	su]	lts									
	-1.37	-1.41	-1.29	-1.03	-0.85	-0.92	+0.84	+1.04	+1.06	+0.87	+0.69	+0.60
	-0.41	-0.14	-0.02	+0.09	+0.05	+0.23	+1.03	+0.70	+0.39	+0.05	-0.15	-0.25
	+0.22	+0.69	+0.72	+0.61	+0.68	+0.69	+0.94	+0.47	-0.04	-0.33	-0.39	-0.35
	+1.94	+1.53	+1.26	+1.09	+1.02	+0.90	-2.41	-2.28	-1.88	-1.31	-0.87	-0.57
	+2.08	+1.62	+1.51	+1.34	+1.01	+0.76	-2.65	-2.47	-1.98	-1.32	-0.74	-0,45
	+2.19	+1.88	+1.80	+1.26	+0.79	+0.46	-2.94	-2.60	-2,03	-1.08	-0.55	-0.16
	+2.54	+2.23	+1.75	+0.96	+0.38	-0.02	-3.19	-2.68	-1.83	-0.83	-0.15	+0.26
	+2.96	+2.24	+1.45	+0.39	-0.21	-1.16	-3.33	-2.53	-1.62	-0.33	+0.42	+0.98
	+3.06	+1.92	+0.85	-0.45	-1.75	+0.07	-3.32	-2.32	-1.12	+0.45	+1.17	-0.13
	+2.79	+1.24	-0.10	-2.39	-0.93	+1.45	-3.13	-1.80	-0.27	+1.42	+0.38	-1.37
	+2.10	+0.25	-2.02	-2.00	+0.05	+2.95	-2.55	-0.96	+0.72	+1.04	-0.56	-2.83
	+1.19	-1.44	-1.67	-1.34	+1.18	+4.68	-1.78	-0.22	+0.25	+0.33	-1.73	-4.71
	-0.45	-1.11	-1.41	-0.72	+2.47	+6.58	-1.38	-0.75	-0.18	-0.37	-3.11	-7,00
	+0.08	-0.81	-1.12	+0.38	+3.97	+8,45	-2.20	-1.34	-0.73	-1.64	-4.80	-9.29
_	+0.41	-0.41	-0.40	+1.68	+5.66	+10.17	-2.84	-2.08	-1.69	-3.01	-6.60	-11.46
	+0.75	+0.29	+0.76	+3.38		+11.45	-3.71	-3.19	-2,92	-4.80		-12.72
	+1,60	+1.47	+2.16	+6,72		*10.66	-5.21	-5.01	-4,68	-8.31	-11.40	
	+2.83	+2.59	+4.35		+10.17	+1.60	-7.29	-7.14	-7.58		-12.62	-4.17
	+4.45	+4.21	+6.53	+9.69	+8.19	-8.20		-10.55	-11.23	-13.99		-0.37
	+7.00	+6.00		+18.54	-6.28				-13.10		-7.91	-5.46
	+10.54	+2.54	+18.54	-6.46	-2.46	-9.46	-21.46	-21.46	-21,46	-21.46	-21.46	-21.46

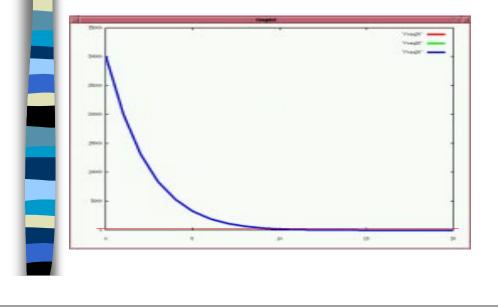


# EV visualization and frequency

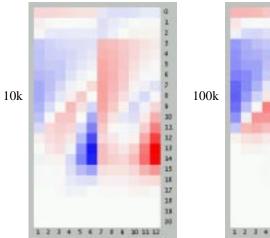


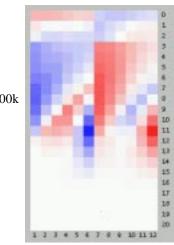


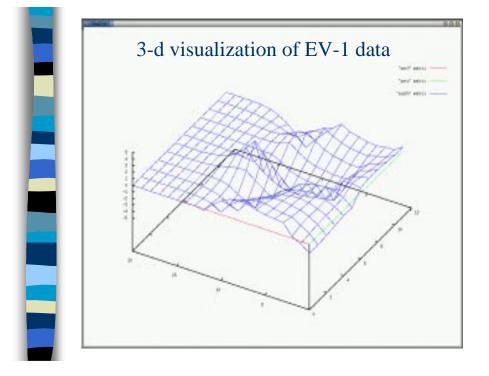
# Frequency vs. number of pebbles

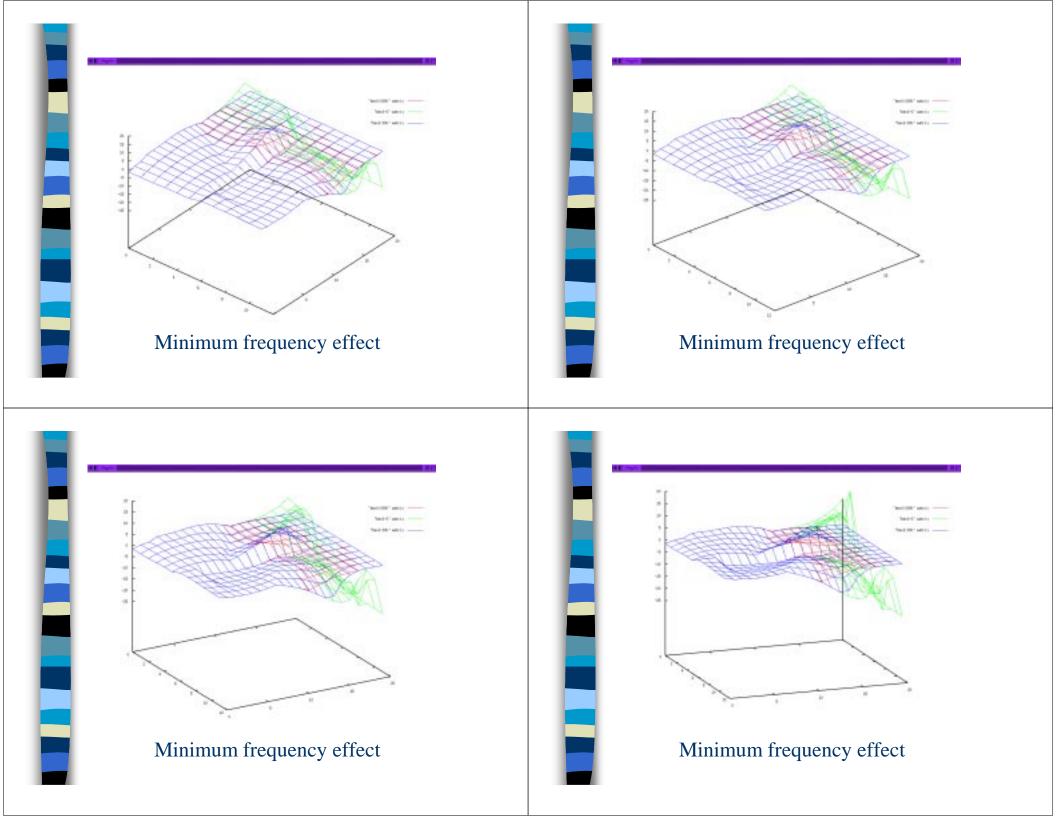


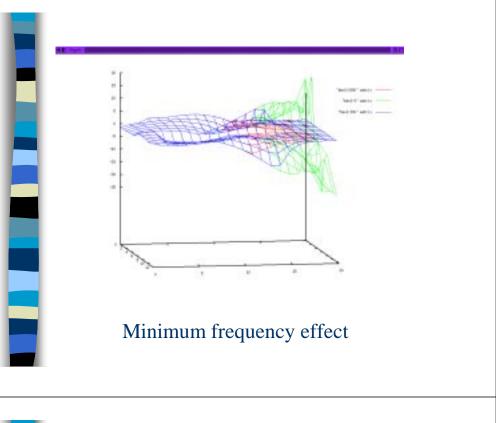
# Minimum frequency (Bayesian)

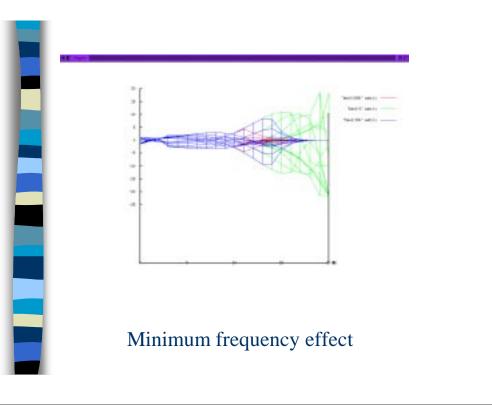


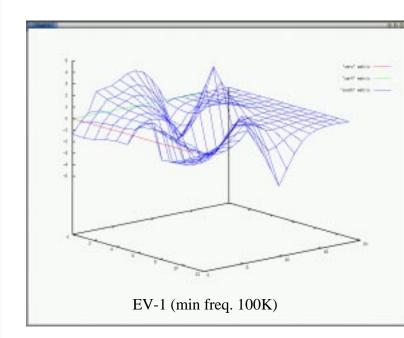


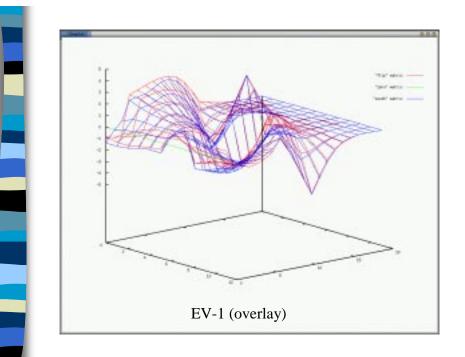


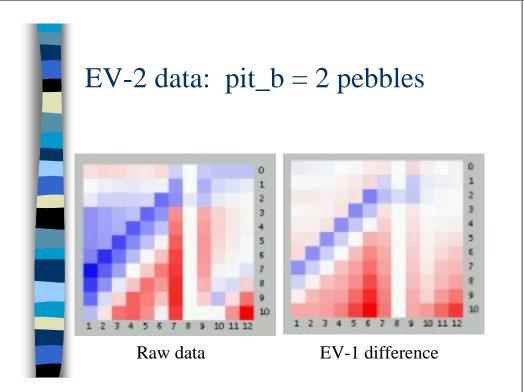










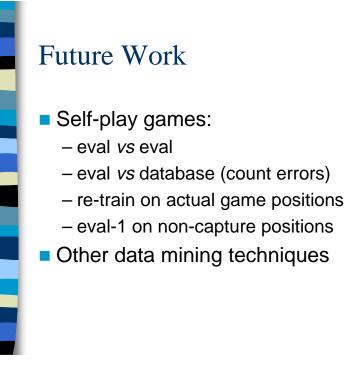


# **Evaluation Function Results**

frequency	1000
64694821	334
22897612	118
105944287	547
193536720	1000
293523543	+1.52
	64694821 22897612 105944287 193536720

eval-2	lose	draw	win	sum
lose	237	33	37	308
draw	37	20	32	90
win	59	63	477	600
sum	334	118	547	1000

Correct:	553		Score:	387			
Mean squa	ared error:	25.14	25.14				
adjusted	mobility						
Correct:	576		Score:	415			
Mean squa	ared error:	22.84	22.84				
eval-1							
Correct:	723		Score:	617			
Mean squa	ared error:	13.84					
eval-2							
Correct:	736		Score:	639			



# Conclusions

- Successfully extracted knowledge from the Awari endgame database
- Built relatively good evaluation functions
- eval-1 and eval-2 also work well for unbalanced positions (*eg.* diff=3), and can be further improved
- Discovered knowledge enhances human understanding of Awari