# Artificial Intelligence for StarCraft

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## What is StarCraft?

Blizzard - 1998 Real-Time Strategy War Simulation ► Typical Game: Gather Resources Build Town / Army Combat With Enemies Properties Multi-Unit Control **Imperfect Information** Simultaneous Actions Real-Time (24fps)





### Motivation – Why StarCraft?

Solving hard AI problems Applicable to other fields Game Design / Testing Better single player experience Training for professionals Reduce Human Testers Game Balance Creating Strong AI agents Beat the best AI bots Beat the humans! Humans are VERY good



#### **Professional Players**



#### 300-500 Actions Per Minute (APM)

#### Blizzard World Championships





Salary
Not Included

1.	MC	Jang, Min Chul	\$409,221.84
2.	💽 Mvp	Jung, Jong Hyun	\$379,290.06
3.	💽 NesTea	Lim, Jae Duk	\$268,394.80
4.	💽 Polt	Choi, Sung Hoon	\$241,902.77
5.	🚺 Stephano	Ilyes Satouri	\$232,202.31
6.	💌 MMA	Moon, Sung Won	\$220,549.24
7.	💽 Leenock	Lee, Dong Nyung	\$213,270.15
8.	💽 DongRaeGu	Park, Soo Ho	\$212,641.12
9.	💽 HerO	Song, Hyeon Deok	\$196,835.26
0.	💽 PartinG	Won, Lee Sak	\$189,718.77

### Traditional Game AI



#### How large is StarCraft?

#### Avg Map Size: 128 \* 128

#### Number of Unit Types: ~50 Number of Units: ~200

#### How large is StarCraft?



Does Not Include: Unit Types, Health, Attacks, Resources, etc







## StarCraft Strategy Flow

High-Level Strategy





## **Build Order Planning**

**Build-Order** 

Planning

#### Depth-First Branch & Bound

Cybernetics Core 17/38 Frame: 4776 216 Gateway 3m 19s Time: Lost: S 0 0 E 0 0 Build Order Info: ?inish: 5714 Squads Seen Unit Information: UNIT NAME SIZE LOCATION UNIT NAME # X rotoss Citadel of Adun Protoss Probe Protoss Probe Protoss Probe Protoss Templar Archives Protoss Probe Protoss Probe Protoss Dark Templar Protoss Dark Templar **Real-Time** Search

"Build-order optimization in StarCraft" (2011 AIIDE)

#### Multi-Agent Pathfinding

## Multi-Agent Pathfinding







Move As Group

## **Multi-Agent Pathfinding**



#### StarCraft 1: Single-Agent

#### StarCraft 2: Flocking (but cheats)

#### Combat Policies

## **RTS** Combat

Multiple Unit Types HP, Damage Individual Unit Control Attack, Move, Reload ▶ Real-Time 24 FPS Simultaneous Moves Durative Actions



#### **RTS Combat - Actions**



Exponential Branching Factor 😕

### Alternating Move Tree Search



#### Tree Search for RTS Combat



### Combat Research: SparCraft

Player Type: Time Limit: Max Children; Move Ordering: Player To Nove: Opponent Hodel;	AlphaBeta 40mm 20 ScriptFirst Alternate None	Flayer 1 Settings Flayer Type: Time Limit: C Value: Max Traversals: Max Children: Move Ordering: Flayer To Move: Opponent Model:	UCT 40ms 1.6 5000 20 ScriptFirst Alternate None	Player 1: Player 2: State #: Units: Pl 0: P2 0: 0 vs 0	AlphaBeta UCT 0 of 10 32 AlphaBeta UCT 0.0000000			Martin Street
Nodes Searched: AB Value: Max Depth:	50 20 2	Player 2 Scatch Res Traversals: Nodes Visited: Total Visits: Nodes Created:	1112 20 21 41 20					
Alph	a-Beta	U	СТ		Portfolic	Greedy	/ Search	

Portfolio Greedy Search and Simulation for Large-Scale Combat in Starcraft 2013 CIG – http://code.google.com/p/sparcraft

#### UAlbertaBot - Overview

Uses Protoss Race Aggressive Strategy ► CIG Results 2011 CIG – 2<sup>nd</sup> 2012 CIG – 2<sup>nd</sup> 2013 CIG – 2<sup>nd</sup> ► AIIDE Results 2011 AIIDE – 2<sup>nd</sup> 2012 AIIDE – 3<sup>rd</sup> 2013 AIIDE – 1<sup>st</sup>



### UAlbertaBot Design



Open Source: http://code.google.com/p/ualbertabot

#### UAlbertaBot - CMPUT 350

University of Alberta CS Course ► 3<sup>rd</sup> Year Undergraduates Beginning of Course No C++ knowledge No AI knowledge End of Course Project Modify UAlbertaBot Compete in Class Competition We use their improvements in UAlbertaBot

# AIIDE StarCraft AI Competition

#### **Tournament Report**

#### www.StarCraftAICompetition.com

"2013 REPORT"



Home 2013 Report Rules

Software

Registration

Media/Files

Contact

#### 2013 StarCraft AI Competition Files (BroodWar 1.16.1, BWAPI 3.7.4)

Bot Name	Author	Affiliation	Race	Download
Aiur	Florian Richoux	University of Nantes	Protoss	<u>bot / replays</u>
BTHAI	Johan Hagelback	Blekinge Institute of Technology	Terran	bot / replays
ICE	Kien Quang Nguyen	<u>Ritsumeikan University</u>	Terran	bot / replays
Nova	Alberto Uriarte	Drexel University	Terran	bot / replays
Skynet	Andrew Smith	Independant	Protoss	bot / replays
UAlbertaBot	David Churchill	University of Alberta	Protoss	bot / replays
Xelnaga	Ho-Chul Cho	Sejong University	Protoss	<u>bot / replays</u>
Ximp	Tomas Vajda	Comenius University	Protoss	bot / replays

- 2013 Official Results
- 2013 Competition Map Pack

#### 2013 StarCraft AI Competition

Hosted at U of A

Computing Science Department

Blizzard provides prizes for winners

8 Participants

■ 2012 - 10, 2011 - 13

Round Robin Format

6000 games played = 200 Rounds

Games played up to 64x 'human' speed

Penalties for slow computations

#### AIIDE StarCraft AI Competition

Most AI bots written in C++ Can be written in Java as well BWAPI Library used for StarCraft interface API created through reverse engineering Blizzard does not support BWAPI Lets us use it for academic competitions

StarCraft 2 not allowed

### **Tournament Environment**

UofA Computer Lab ▶ 20 Intel E8500 CPU 2.4ghz Dual Core 4 GB of RAM Read/Write specific folders for learning Duration 200 Rounds • 24 hours for 4 days



#### **Tournament Software**





## Participants



Author	Affiliation	Race
Florian Richoux	University of Nantes	Protoss
Johan Hagelback	Blekinge Institute of Tech.	Terran
Kien Quang Nguyen	Ritsumeikan University	Terran
Alberto Uriarte	Drexel University	Terran
Andrew Smith	Independant	Protoss
David Churchill	University of Alberta	Protoss
Ho-Chul Cho	Sejong University	Protoss
Tomas Vajda	Comenius University	Protoss
	AuthorFlorian RichouxJohan HagelbackKien Quang NguyenAlberto UriarteAndrew SmithDavid ChurchillHo-Chul ChoTomas Vajda	AuthorAffiliationFlorian RichouxUniversity of NantesJohan HagelbackBlekinge Institute of Tech.Kien Quang NguyenRitsumeikan UniversityAlberto UriarteDrexel UniversityAndrew SmithIndependantDavid ChurchillUniversity of AlbertaHo-Chul ChoSejong UniversityTomas VajdaComenius University

## 2013 Results

	Games	Win	Loss	Win %
UAlbertaBot	1400	1154	246	82.43
Skynet	1399	1018	381	72.77
Aiur	1400	844	556	60.29
Ximp	1400	774	626	55.29
Xelnaga	1399	699	700	49.96
ICEStarCraft	1399	669	730	47.82
Nova	1398	384	1014	27.47
BTHAI	1399	55	1344	3.93
Total	5597	5597	5597	N/A

### Win Percentage Over Time



#### Past Results

2011 – Skynet, UAlbertaBot, Aiur
2012 – Skynet, Aiur, UAlbertaBot
2013 – UAlbertaBot, Skynet, Aiur

What Changed in UAlbertaBot?
Bug fixes in UAlbertaBot behaviour
Improved Combat Simulation
If (Skynet) DarkTemplarRush();

### Man vs. Machine

#### 2012 / 2013

- Bakuryu (Germany)
- ICCup: A- Zerg
- Top 20 Non-Korean
- Humans Dominate
  - Bots exploited easily
  - Human strategies are very strong
  - Bots cannot adapt
  - Bots lack global game context, too local



#### Man vs. Machine



#### **Additional Discussion**

▶ When will we beat humans? My Estimate: 10 years Will humans still play StarCraft in 10 years? ▶ What improved this year? Progress in research, but not bot strength Aiur learned well ▶ What needs work? Bots exploited by humans easily Bad overall strategy selection

#### ► WE NEED TO COLLABORATE

### Collaboration

Diver

#### UAlbertaBot

- Combat Simulation
- Build-Order Planner
- Skynet
  - Good Path-finding
  - Solid Mid-Game Strategy
- Aiur
  - Many Strategies
  - Good Learning
- BroodwarBotQ
  - Opponent Modeling
- Nova
  - Kiting

#### Resources

StarCraft AI Competition & Software www.StarCraftAICompetition.com UAlbertaBot Project http://code.google.com/p/ualbertabot SparCraft Project http://code.google.com/p/ualbertabot ► My Website http://www.cs.ualberta.ca/~cdavid/

# Thank You! ありがとう