Microsoft

Video Games and the Road to Collaborative AI

Katja Hofmann
Machine Intelligence and Perception, MSR Cambridge

@katjahofmann

Futurism

Artificial Intelligence

The Rise of Conscious AI is Just Decades Away

by Dom Galeon on November 1, 2017 11013

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NEWS ANALYSIS

After a big 2016, next year may be A.I. tipping point

Artificial intelligence progress expected to continue to accelerate in coming year

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NEWS ANALYSIS

After a big 2016, next year may be A.I. tipping point

Artificial intelligence progress expected to continue to accelerate in coming year

Intelligent Machines

Progress in AI isn't as Impressive as You Might Think

A new report gauges how far we've come, dampening ideas that machines are approaching human-type intelligence.

by Will Knight November 30, 2017

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Legg-Hutter Intelligence

$$\Upsilon := \sum_{\mu \in E} 2^{-K(\mu)} V_{\mu}^{\pi}$$

Legg, S., & Hutter, M. (2007). Universal Intelligence: A Definition of Machine Intelligence. *Minds and Machines, 17 (4), pages 391-444*.

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Jan Leike & Marcus Hutter (2015). Bad Universal Priors and Notions of Optimality. *Conference on Learning Theory (COLT) 40, 1–16.*

Tech giants open virtual worlds to bevy of AI programs

Artificial-intelligence algorithms can learn a lot from playing immersive 3D video games.

Davide Castelvecchi

14 December 2016 | Corrected: 21 December 2016

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Matthew Tostevin/Reuters

The *Minecraft* video game is popular with children; now a version is being used to test artificial-intelligence programs.

The Economist

Artificial intelligence

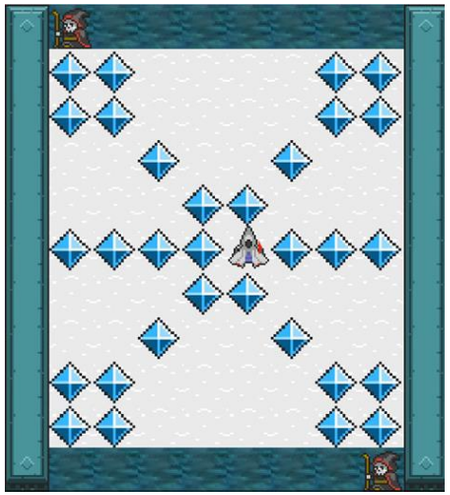
Why AI researchers like video games

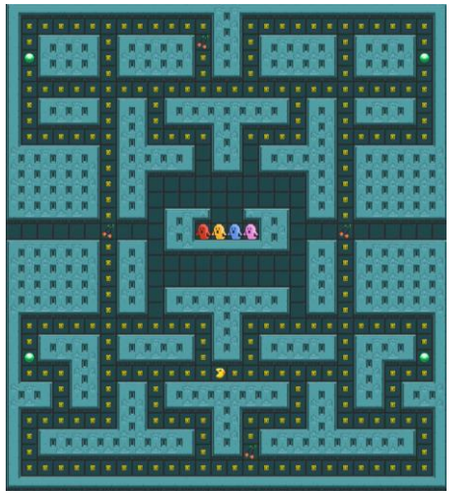
Games help them understand reality

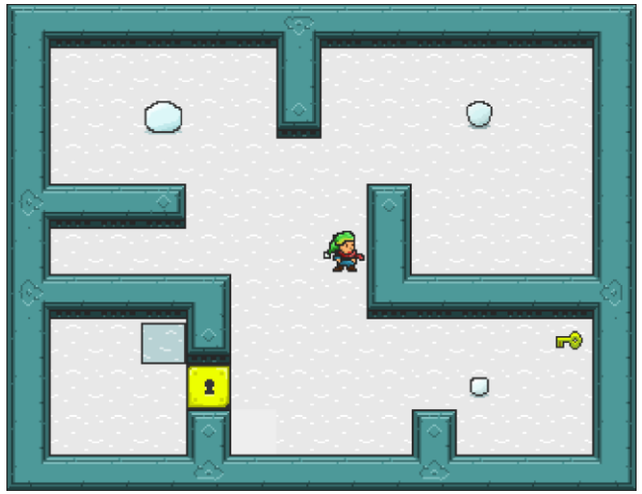
José Hérnandez-Orallo, Marco Baroni, Jordi Bieger, Nader Chmait, David L. Dowe, Katja Hofmann, Fernando Martínez-Plumed, Claes Strannegård, Kristinn R. Thórisson. A New AI Evaluation Cosmos: Ready to Play the Game? AI Magazine, 38 (3), pages 66-69 (2017).

General Video Game (GVGAI) Competition

Aim: general video game playing agent







Diego Perez-Liebana

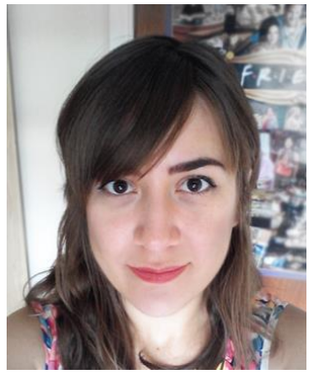
Spyridon Samothrakis

Julian Togelius

Tom Schaul

Simon Lucas

Jialin Liu


Raluca Gaina

Ahmed Khalifa

Diego Perez-Liebana, Spyridon Samothrakis, Julian Togelius, Tom Schaul, Simon Lucas, Adrien Couetoux, Jerry Lee, Chong-U Lim, Tommy Thompson. The 2014 General Video Game Playing Competition, *IEEE Transactions on Computational Intelligence and AI in Games*, DOI: 10.1109/TCIAIG.2015.2402393 (2015).

VGDL

Games described in Video Game Description Language (VGDL)

```
BasicGame key_handler=Pulse square_size=50

    SpriteSet
        hole   > Immovable color=DARKBLUE img=hole
        ground > Immovable img=water
        avatar > MovingAvatar
        bbox > Passive
            box    >  img=box
            boxin  >  img=city

    LevelMapping
        A > avatar ground
        0 > hole
        * > box ground
        . > ground

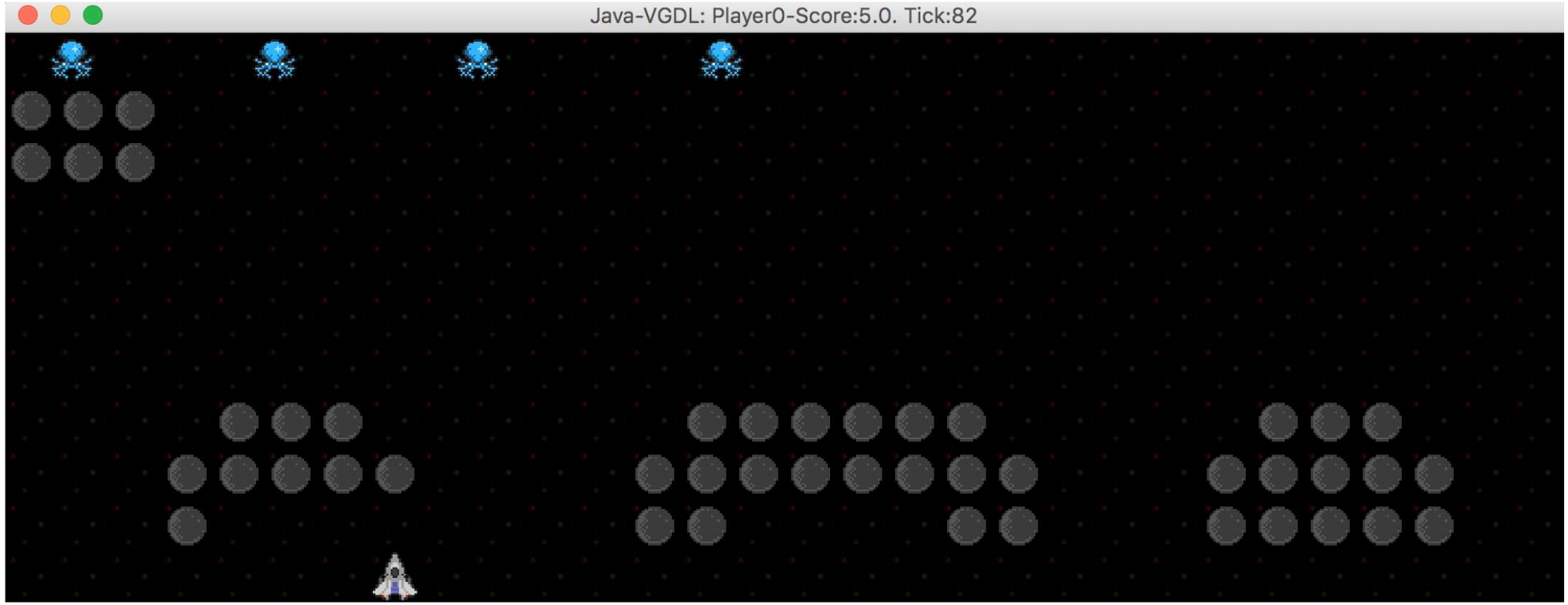
    InteractionSet
        avatar wall > stepBack
        bbox avatar  > bounceForward
        bbox wall bbox   > undoAll
        box hole    > transformTo stype=boxin scoreChange=1
        boxin ground > transformTo stype=box scoreChange=-1

    TerminationSet
        SpriteCounter stype=box    limit=0 win=True
```

```
wwwwww.wwwww
w....www...w
w.**.....wAw
w.*.w000...w
w...wwwwwwww
wwwww.......
```

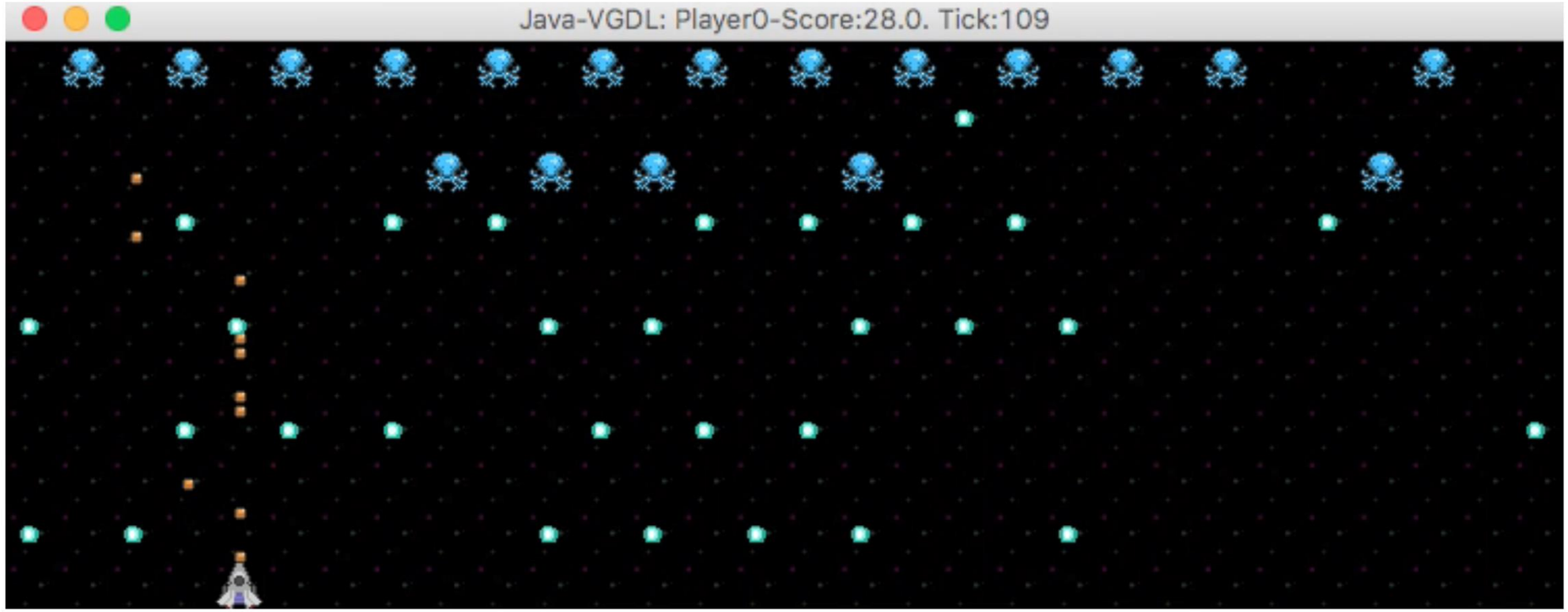
Tom Schaul. A Video Game Description Language for Model-based or Interactive Learning. In Proceedings of the IEEE Conference on Computational Intelligence in Games, pages 193–200, 2013.

Example game: Aliens



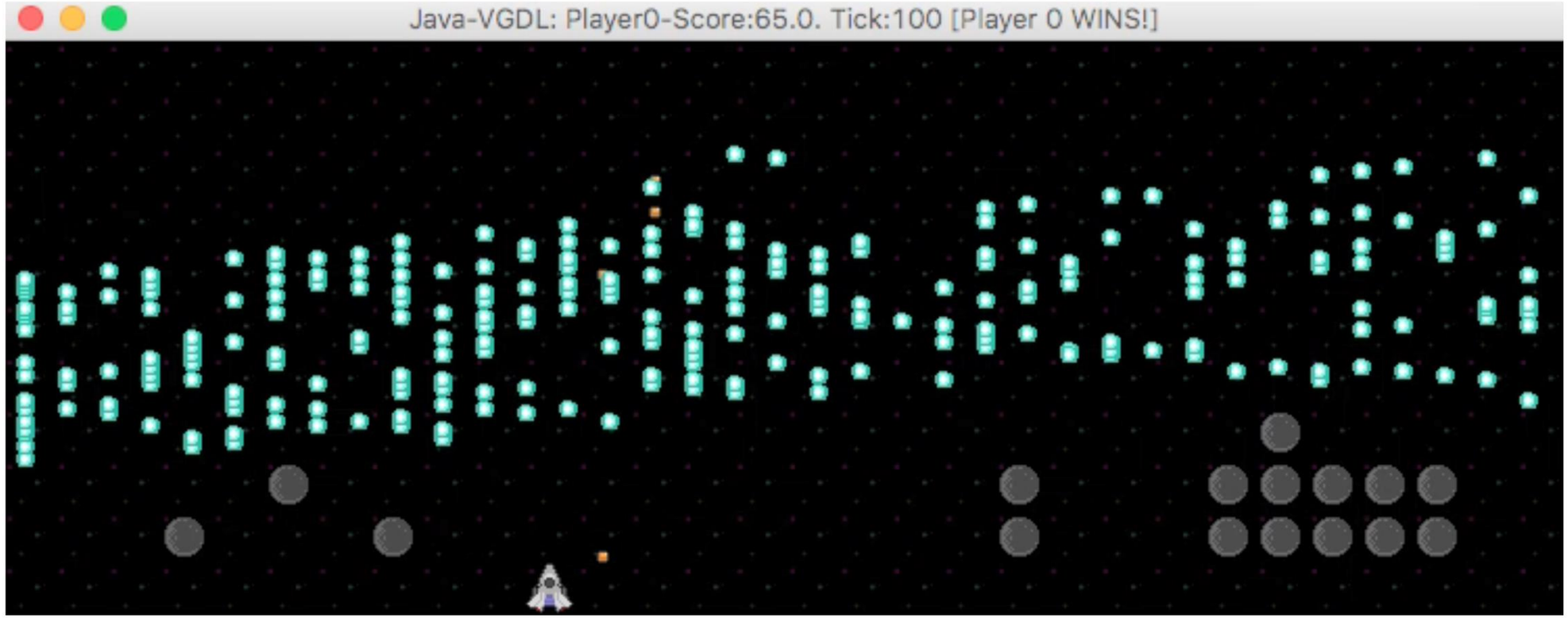
For videos see:
https://www.youtube.com/playlist?list=PLsz4FpDoCTzyRJqDV7VpT2hO02gHOZwA5

Aliens v2



For videos see:
https://www.youtube.com/playlist?list=PLsz4FpDoCTzyRJqDV7VpT2hO02gHOZwA5

Aliens v3



For videos see:
https://www.youtube.com/playlist?list=PLsz4FpDoCTzyRJqDV7VpT2hO02gHOZwA5

Project Malmo

A platform for AI experimentation, built on Minecraft

Open source on GitHub: github.com/microsoft/malmo

Matthew Johnson, Katja Hofmann, Tim Hutton & David Bignell. The Malmo Platform for Artificial Intelligence Experimentation. International Joint Conference on Artificial Intelligence, (IJCAI), pages 4246-4247, 2016.

Microsoft / malmo

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Project Malmo is a platform for Artificial Intelligence experimentation and research built on top of Minecraft. We aim to inspire a new generation of research into challenging new problems presented by this unique environment. --- For installation instructions, scroll down to *Getting Started* below, or visit the project page for more information: https://www.microsoft.com/en-us/resea...

Edit

Add topics

1,195 commits | 18 branches | 17 releases | 17 contributors | MIT

Branch: master | New pull request | Create new file | Upload files | Find file | Clone or download

DaveyBiggers Merge pull request #630 from Phantomb/patch-1 ... Latest commit d3057d3 16 days ago

.travis	Experimental fix for failing travis CI builds	6 months ago
ALE_ROMS	Applied MIT license.	2 years ago
Malmo	Annoying workaround required for pre 2.7.9 versions of python	2 months ago
Minecraft	Can't use OpenGL 3	2 months ago
Schemas	Adding new video producers	3 months ago
cmake	Update FindXsd.cmake	a year ago
doc	Update install_windows.md	28 days ago
sample_missions	Futurising validation test	2 months ago

The Malmo Platform

API for interactive agents in Mincraft

Create directly in Minecraft, through mission XML and/or API

```
<ServerHandlers>
  <FlatWorldGenerator generatorString="3;7,220*..."/>
    <DrawingDecorator>
    [...]
    <DrawCuboid x1="-2" y1="45" z1="-2" x2="7"
y2="45" z2="18" type="lava" />  <!-- lava floor -->
    <DrawCuboid x1="1" y1="45" z1="1" [...]
type="sandstone" />  <!-- floor of the arena -->
    <DrawBlock x="4" y="45" z="1" type="cobblestone"
/>  <!-- the starting marker -->
    [...]
</ServerHandlers>
<AgentHandlers>
  <ObservationFromFullStats/>
  <DiscreteMovementCommands>
    <ModifierList type="deny-list">
      <command>attack</command>
    </ModifierList>
  </DiscreteMovementCommands>
  <RewardForTouchingBlockType>
    <Block reward="-100.0" type="lava“
      behaviour="onceOnly"/>
    <Block reward="100.0" type="lapis_block“
      behaviour="onceOnly"/>
  </RewardForTouchingBlockType>
  <RewardForSendingCommand reward="-1"/>
</AgentHandlers>
[...]
```

The Malmo Platform

API for interactive agents in Mincraft

Create directly in Minecraft through missic

Mathew Monfort, Matthew Johnson, Aude Oliva & Katja Hofmann. Asynchronous Data Aggregation for Training End to End Visual Control Networks. AAMAS 2017.

```
<ServerHandlers>
  <FlatWorldGenerator generatorString="3;7,220*..."/>
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    [...]
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    <DrawBlock x="4" y="45" z="1" type="cobblestone"
    !-- the starting marker -->
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     <command>attack</command>
    /ModifierList>
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    Block reward="100.0" type="lapis_block“
     behaviour="onceOnly"/>
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    wardForSendingCommand reward="-1"/>
</AgentHandlers>
[...]
```

The Malmo Platform

API for inter

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Mathew
Hofman
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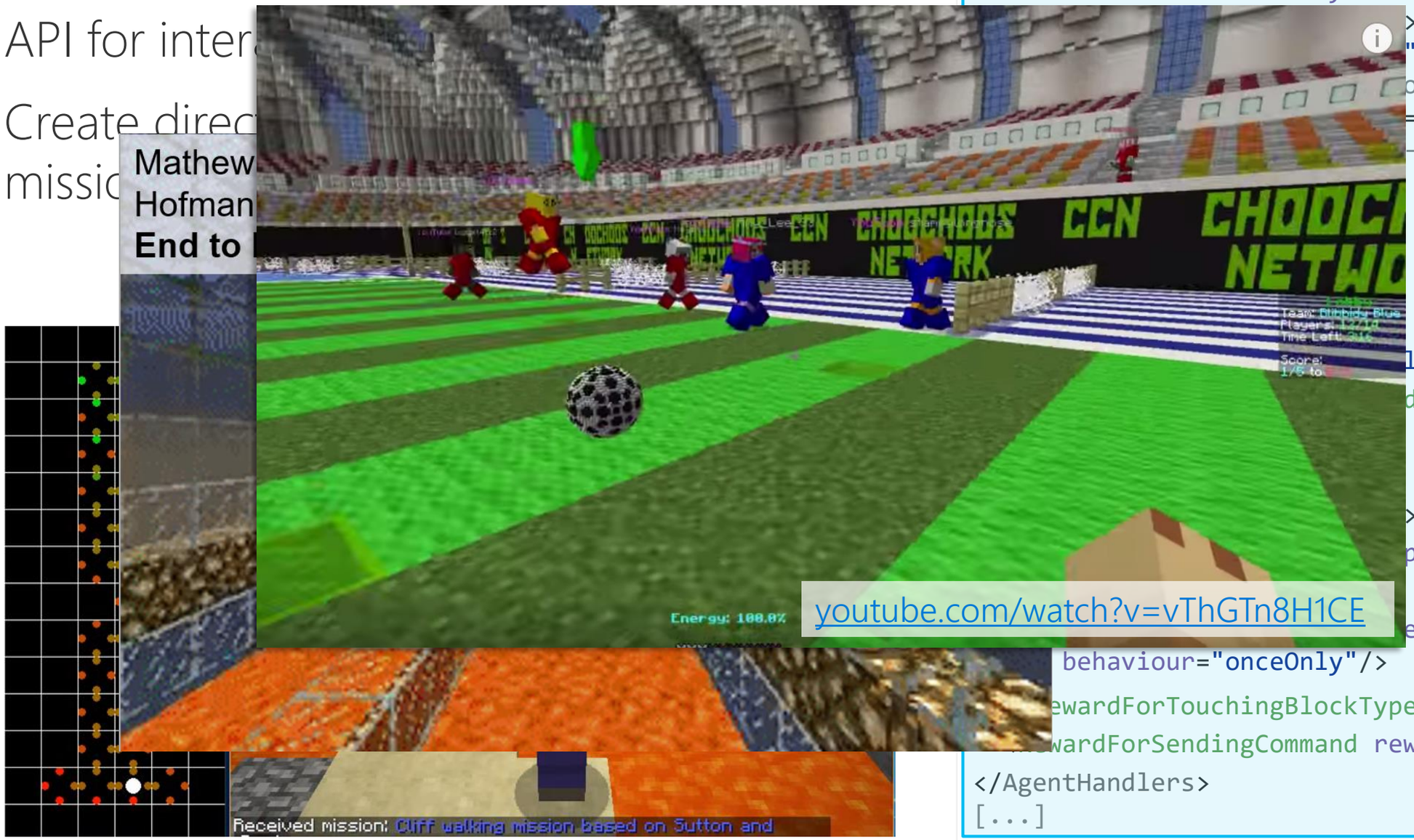

youtube.com/watch?v=vThGTn8H1CE

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    [...]
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                                          >  <!-- lava floor -->
                                  " z1="1" [...]
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                                  >
                                  pe="lava“

                                  e="lapis_block“
                  behaviour="onceOnly"/>
                  ewardForTouchingBlockType>
                  wardForSendingCommand reward="-1"/>
</AgentHandlers>
[...]
```

Psychometric Testing in Minecraft / Project Malmo

Can Minecraft be used as a platform for gamified cognitive tests?

The Psychometrics Centre – University of Cambridge

NSW Education Standards Authority (NESA)

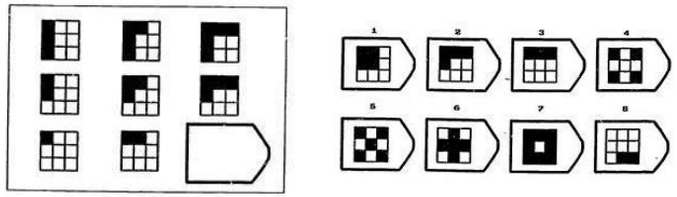
Heinrich Peters

Andrew Kyngdon

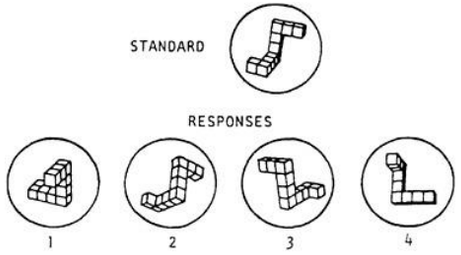
David Stillwell

UNIVERSITY OF CAMBRIDGE
The Psychometrics Centre

Pattern Completion Task



Mental Rotation Task



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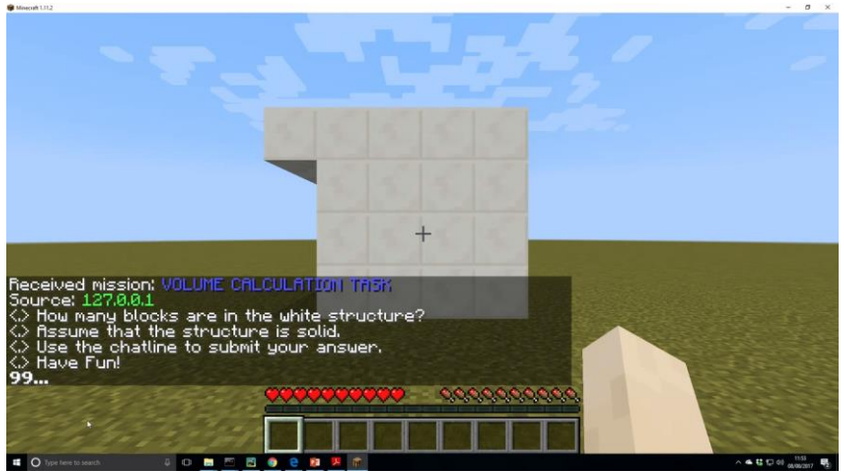
Other Tasks



Perception	Memory	Attention	Social Interaction	Planning	Motivation
Vision	Working	Visual	Communication	Tactical	Subgoal creation
Smell	Episodic	Auditory	Appropriateness	Strategic	Affect-based
Touch	Implicit	Social	Social Inference	Physical	Deferred Gratification
Taste	Semantic	Behavioral	Cooperation	Social	Altruism
Audition	Procedural		Competition		
Cross-modal		**Communication**	Relationships		**Modeling Self / Other**
Proprioceptive	**Reasoning**	Gestural		**Emotion**	Self-Awareness
	Induction	Verbal	**Learning**	Perceived	Other-Awareness
Actuation	Deduction	Musical	Imitation	Expressed	Relationships
Physical Skills	Abduction	Pictorial	Reinforcement	Control	Self-Control
Tool Use	Physical	Diagrammatical	Dialogical	Understanding	Theory of Mind
Navigation	Causal	Language Acquisition	Media-Oriented	Sympathy	Sympathy
Proprioceptive	Associational	Cross-Modal	Experimentation	Empathy	Empathy

Building/Creation	Quantitative
Physical Construction with Objects	Counting Observed Entities
Formation of Novel Concepts	Grounded Small Number Arithmetic
Verbal Invention	Comparison of Quantitative Properties of Observed Entities
Social Organization	Measurement Using Simple Tools

Figure 5. Some of the Important Competency Areas Associated with Human-Level General Intelligence.

Sam Adams, Itmar Arel, Joscha Bach, Robert Coop, Rod Furlan, Ben Goertzel, J. Storrs Hall, Alexei Samsonovich, Matthias Scheutz, Matthew Schlesinger, Stuart C. Shapiro, John Sowa. Mapping the Landscape of Human-Level Artificial General Intelligence. AI Magazine, 33 (1), pages 25-41, 2012.

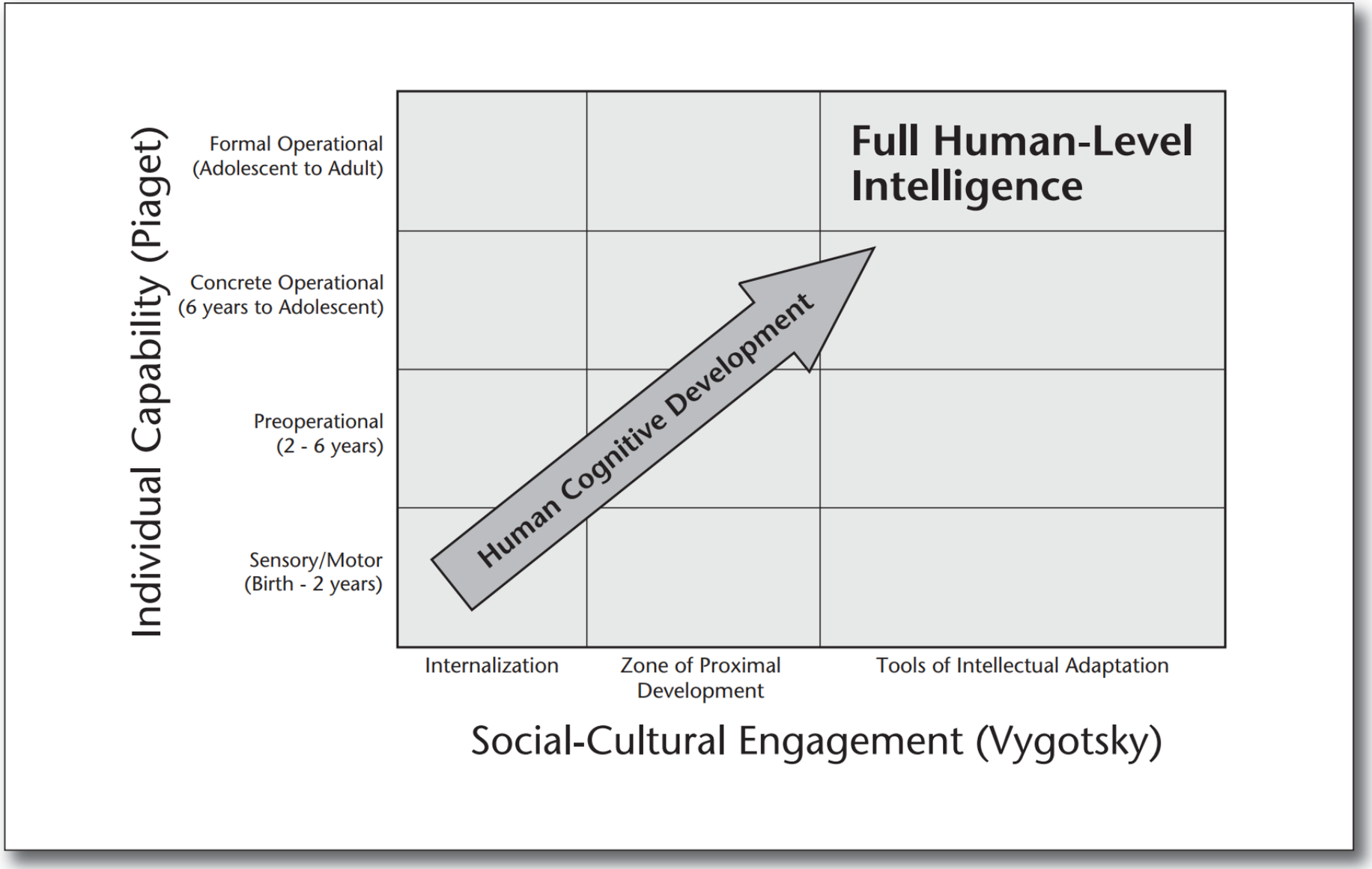


Figure 3. The Landscape of Human Cognitive Development.

Sam Adams, Itmar Arel, Joscha Bach, Robert Coop, Rod Furlan, Ben Goertzel, J. Storrs Hall, Alexei Samsonovich, Matthias Scheutz, Matthew Schlesinger, Stuart C. Shapiro, John Sowa. Mapping the Landscape of Human-Level Artificial General Intelligence. AI Magazine, 33 (1), pages 25-41, 2012.

The Malmo Collaborative AI Challenge

- First round: April/May 2017 (currently planning for next round)
- 83 teams world-wide participated
- This talk: task and key challenges

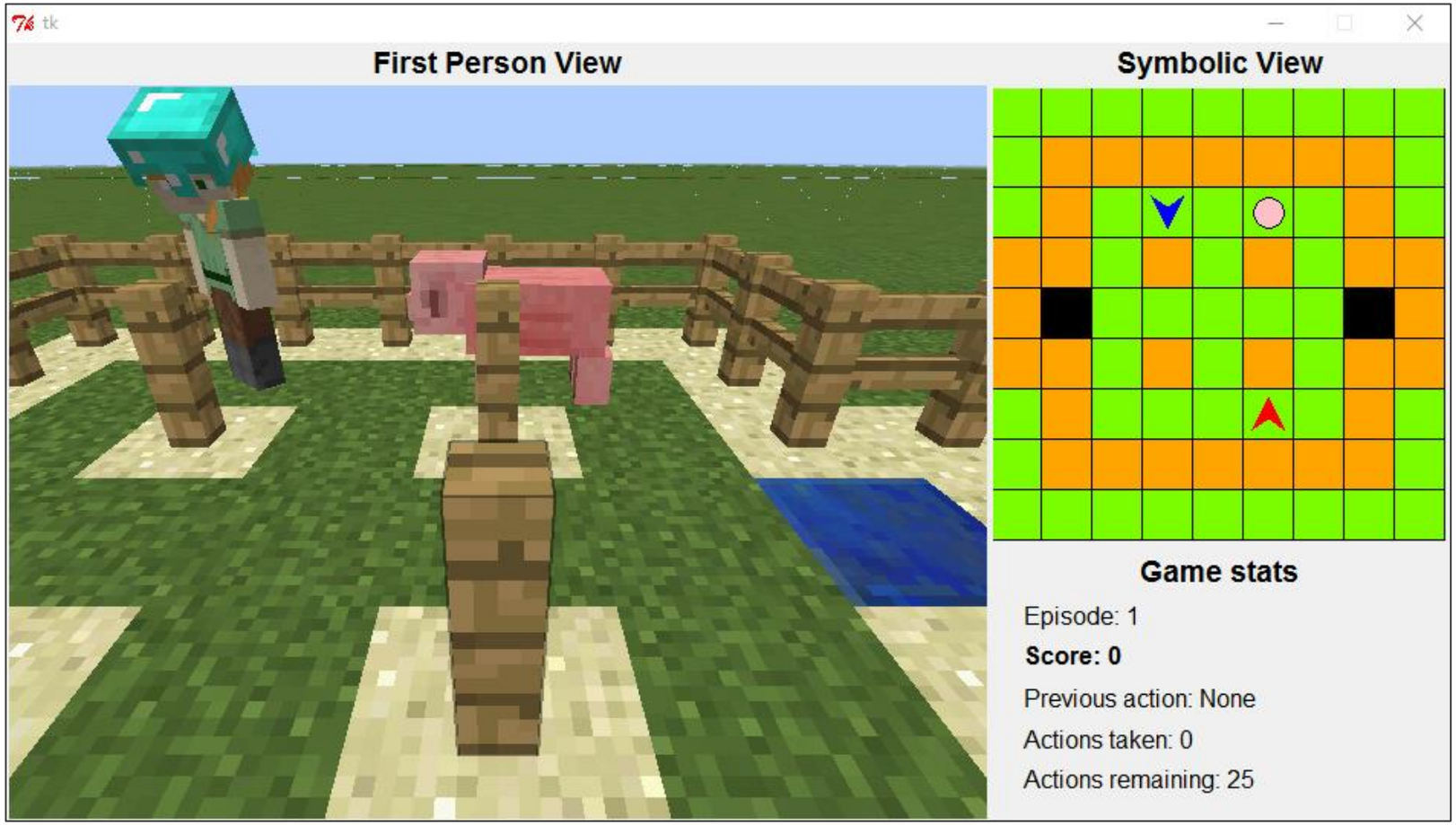
aka.ms/malmo-challenge

Prizes:

Microsoft Research
AI Summer School 2017

Microsoft Azure for Research

Task: Malmo Pig-Chase



Screenshot: Human-Agent pig chase game

Key challenge: reward structure

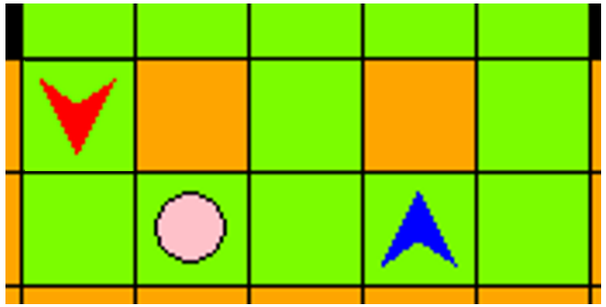
	Stag (Pig)	Hare (Exit)
Stag (Pig)	5, 5	0,1
Hare (Exit)	1,0	1,1

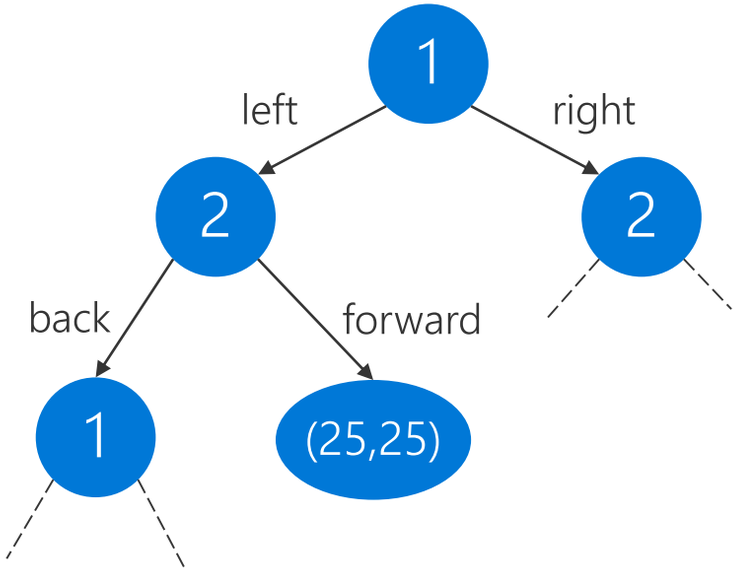
Reward structure for the coordination game "stag hunt"

Key challenge: coordination

	Stag (Pig)	Hare (Exit)
Stag (Pig)	5, 5	0,1
Hare (Exit)	1,0	1,1

Reward structure for the coordination game "stag hunt"



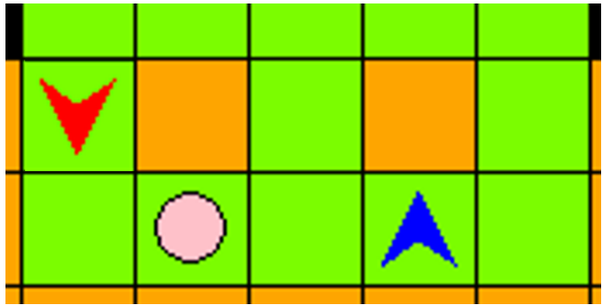


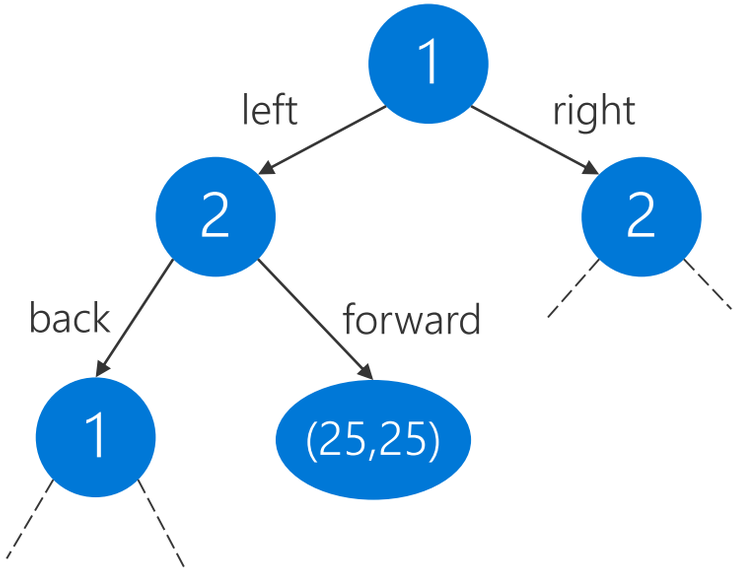
Extensive form game – allows signalling

Key challenge: partial observability

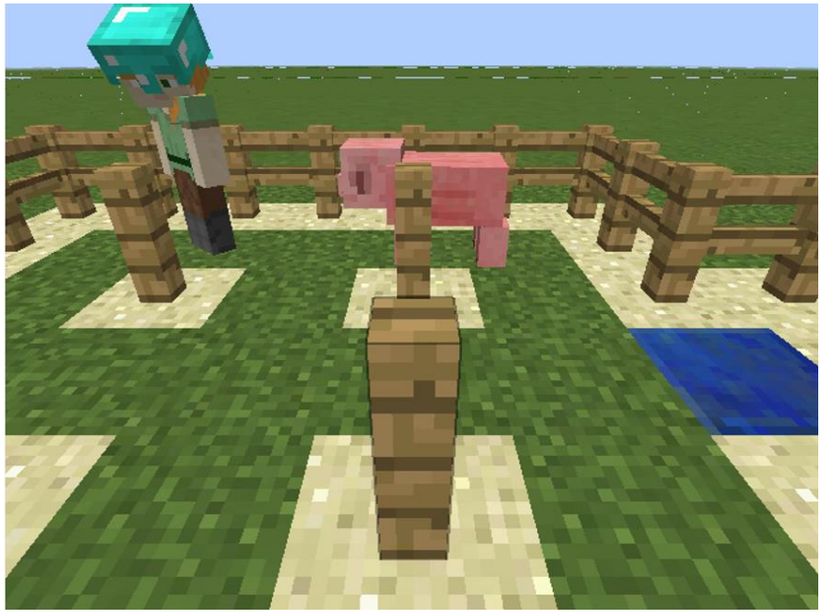
	Stag (Pig)	Hare (Exit)
Stag (Pig)	5, 5	0,1
Hare (Exit)	1,0	1,1

Reward structure for the coordination game "stag hunt"

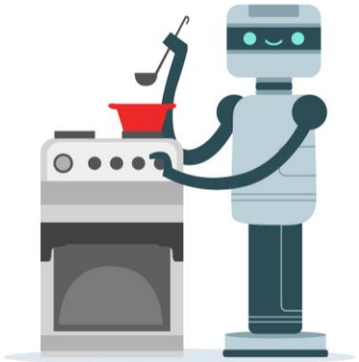


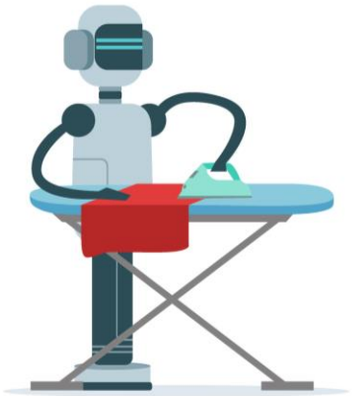


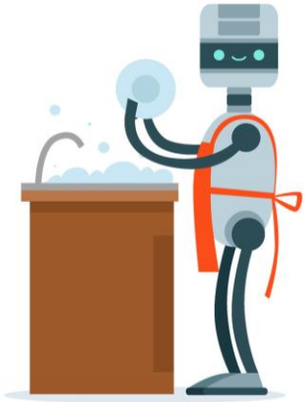
Extensive form game – allows signalling

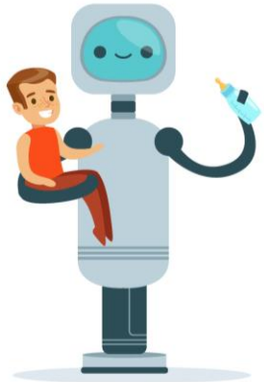


With first-person perspective: imperfect information (partial observability)

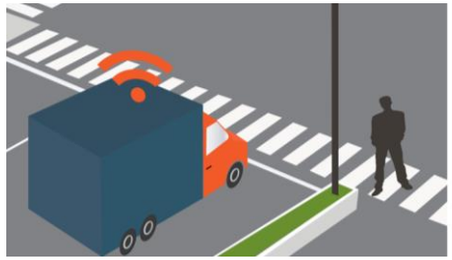


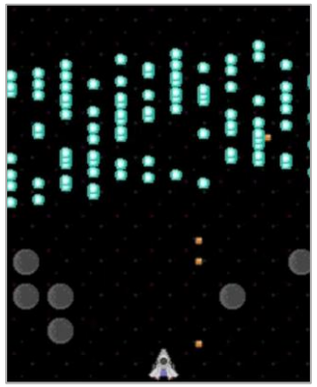


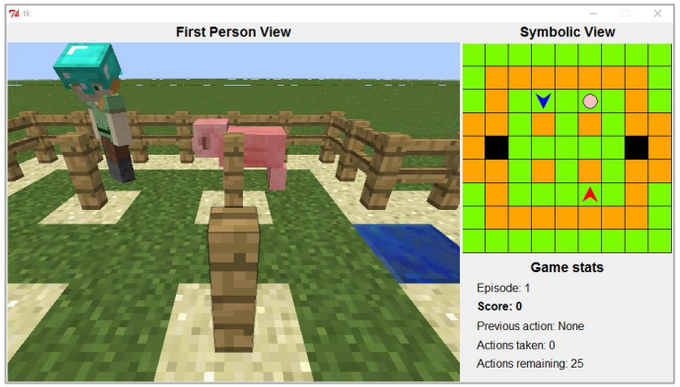


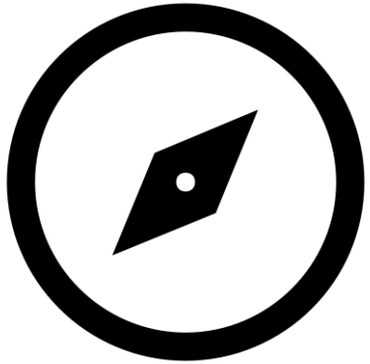


$$\Upsilon := \sum_{\mu \in E} 2^{-K(\mu)} V_\mu^\pi$$









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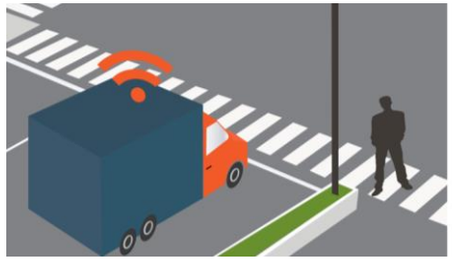

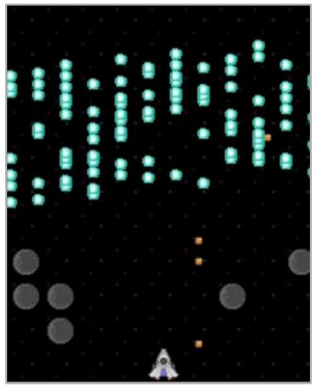

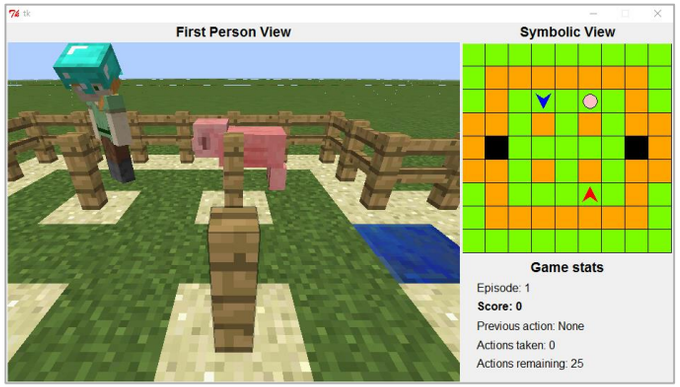

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