

DeepMind

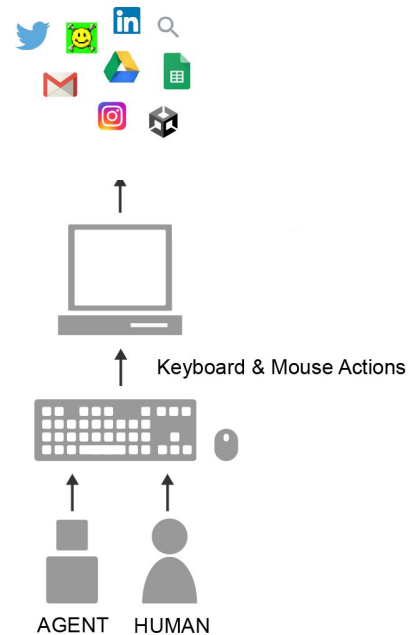
A Data-Driven Approach for Learning to Control Computers

Peter Humphreys, David Raposo, Toby Pohlen, Gregory Thornton,
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Adam Santoro, Timothy Lillicrap



Introduction

It would be useful for machines to use computers as humans do, so that they can aid us in everyday tasks.

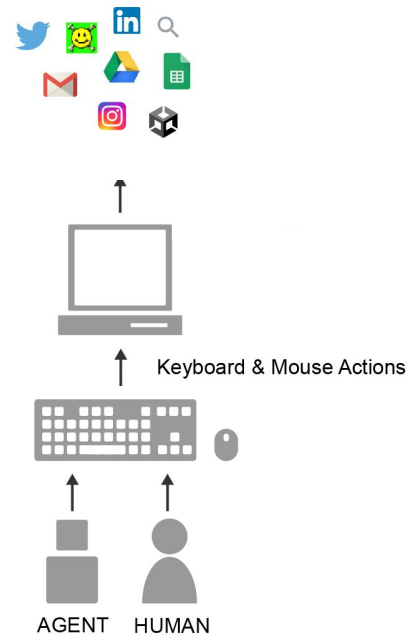


Introduction

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We investigated computer control using keyboard and mouse, with goals specified via natural language.

- Supports transfer & generalisation across tasks.
- Leverage human experience and feedback.



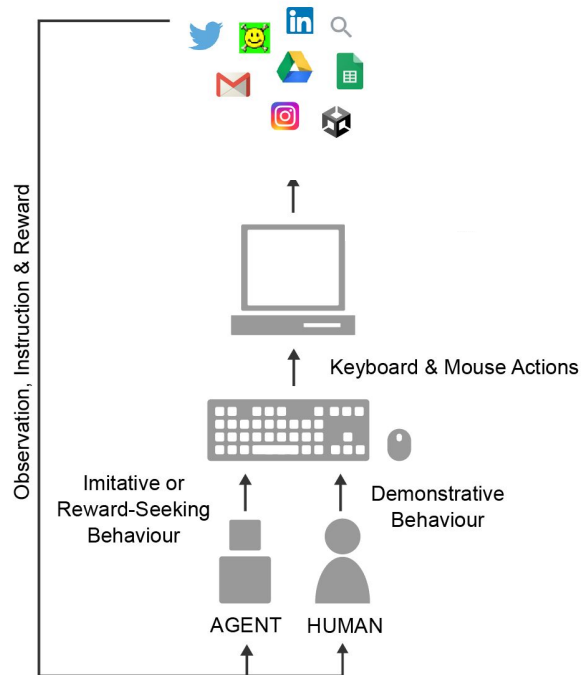
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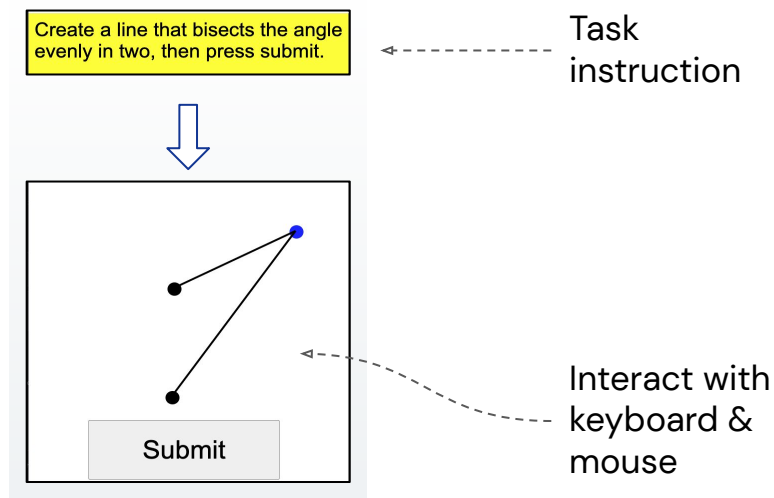
We focus on developing a scalable method centered on **reinforcement learning** combined with **behavioural priors** informed by actual human-computer interactions.



MiniWeb++ Task Suite

A suite of **104 web-browser based tasks** introduced in Liu et al. (2018)
(an extension of the earlier MiniWeb task suite (Shi et al., 2017)).

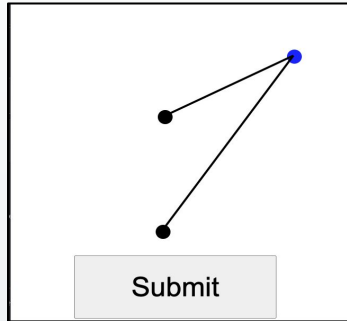
Programmatic rewards are available for each task.



MiniWeb++ Task Suite

Tasks range from simple button clicking to complex form-filling.

Create a line that bisects the angle evenly in two, then press submit.



Solve for x and type your answer into the textbox. Press Submit when done.

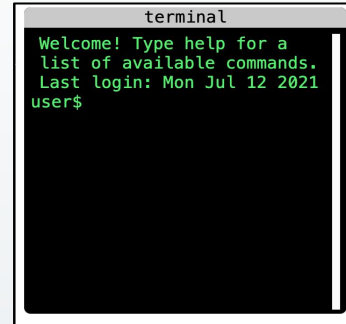


$8 + x = 78$

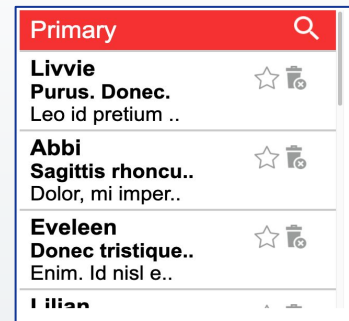
$x =$

Submit

Use the terminal below to delete a file ending with the extension `.html`

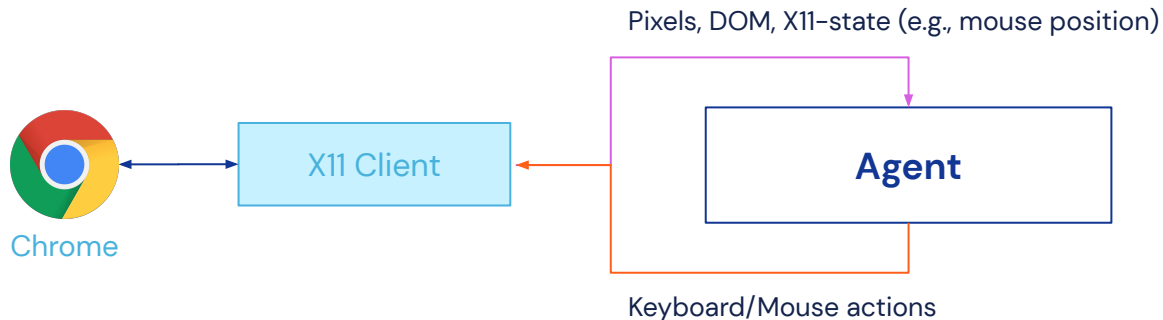


Send a reply to Briney saying "Vitae vitae morbi id..".

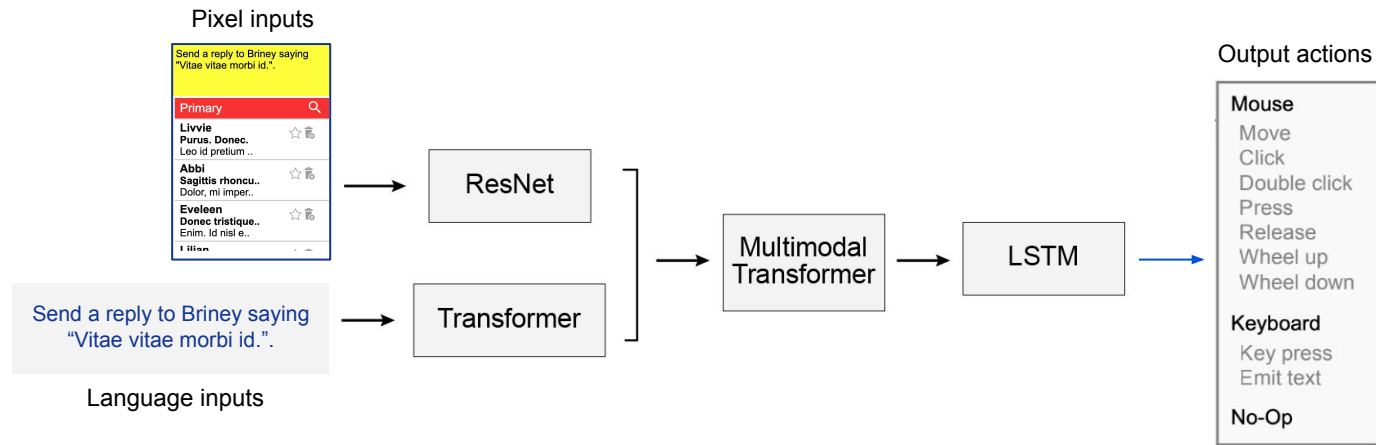


Interface & human data collection

- Our environment connects directly to an X11 server to input mouse & keyboard controls and retrieve observations. This allows agents to use the **same controls as humans** and **minimises domain shift**.
- This interface simplifies recording demonstration data at scale. For this study, we collected over **2.4 million demonstrations** of the MiniWob++ tasks (~1000 times more than previous studies).



MiniWeb Agent

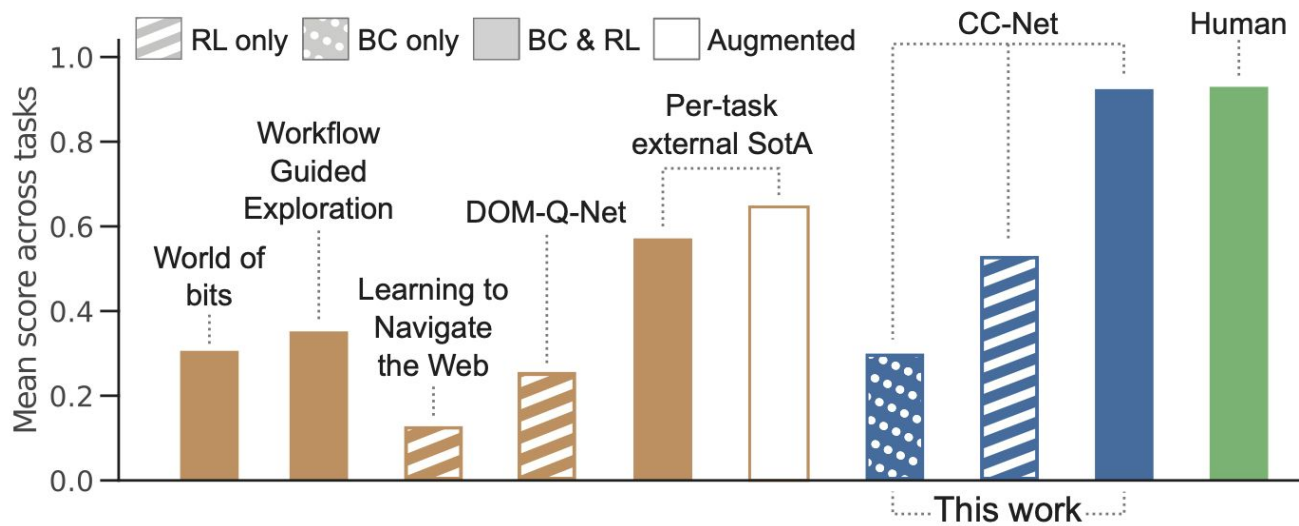


Trained with behavioural cloning (BC) on human data + VMPO (RL) on agent experience.

$$\mathcal{L}(\theta) = \mathbb{E}_{\tau_{\text{EXPERT}}} [-\ln \pi_{\theta}(\mathbf{a} \mid \mathbf{o})] \\ + \mathbb{E}_{\tau_{\text{AGENT}}} [\mathcal{L}^{\text{VMPO}}(\mathbf{a}, \mathbf{o})]$$



Results



Results

Step 3

Book the **shortest** one-way flight from: **WBB** to: **ANV** on 12/03/2016.

Book Your One-Way Flight

From:

To:

Departure Date

Search

Step 6

Book the **shortest** one-way flight from: **WBB** to: **ANV** on 12/03/2016.

Book Your One-Way Flight

WBB

Stebbins, AK (WBB)

Departure Date

Search

Step 9

Book the **shortest** one-way flight from: **WBB** to: **ANV** on 12/03/2016.

Book Your One-Way Flight

Stebbins, AK (WBB)

ANV

Anvik, AK (ANV)

Departure Date

Search

Step 16

Book the **shortest** one-way flight from: **WBB** to: **ANV** on 12/03/2016.

Book Your One-Way Flight

December 2016

12/03/2016

Search

Step 17

Book the **shortest** one-way flight from: **WBB** to: **ANV** on 12/03/2016.

Book Your One-Way Flight

Stebbins, AK (WBB)

Anvik, AK (ANV)

Departure Date

Search

Step 26

Book the **shortest** one-way flight from: **WBB** to: **ANV** on 12/03/2016.

Book Your One-Way Flight

Stebbins, AK (WBB)

Arrives: 9:01 PM

Sat Dec 03 2016

ANV

Duration: 16h 14m

Book flight for \$410

Depart: 9:02 AM

Sat Dec 03 2016

Stebbins, AK (WBB)

Arrives: 12:45 AM

Sat Dec 03 2016

Stebbins, AK (WBB)

Arrives: 9:01 PM

Sat Dec 03 2016

Stebbins, AK (WBB)

Arrives: 9:01 PM

Sat Dec 03 2016

Stebbins, AK (WBB)

Arrives: 9:01 PM

Sat Dec 03 2016

Stebbins, AK (WBB)

Arrives: 9:01 PM

Step 34

Book the **shortest** one-way flight from: **WBB** to: **ANV** on 12/03/2016.

Book Your One-Way Flight

Stebbins, AK (WBB)

Arrives: 7:58 PM

Sat Dec 03 2016

ANV

Duration: 2h 52m

Book flight for \$1100

Depart: 4:46 AM

Sat Dec 03 2016

Stebbins, AK (WBB)

Arrives: 9:01 PM

Sat Dec 03 2016

Stebbins, AK (WBB)

Arrives: 9:01 PM

Sat Dec 03 2016

Stebbins, AK (WBB)

Arrives: 9:01 PM

Sat Dec 03 2016

Stebbins, AK (WBB)

Arrives: 9:01 PM

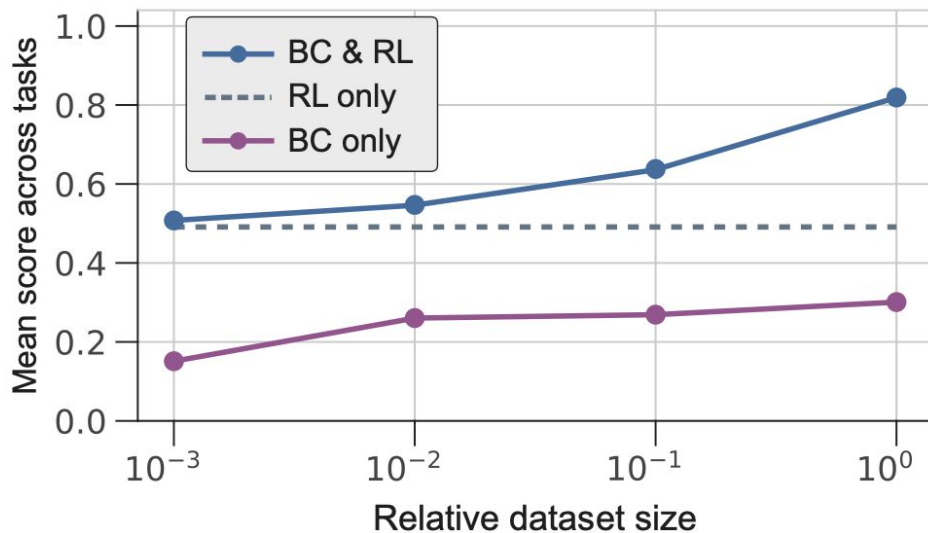
Sat Dec 03 2016

Stebbins, AK (WBB)

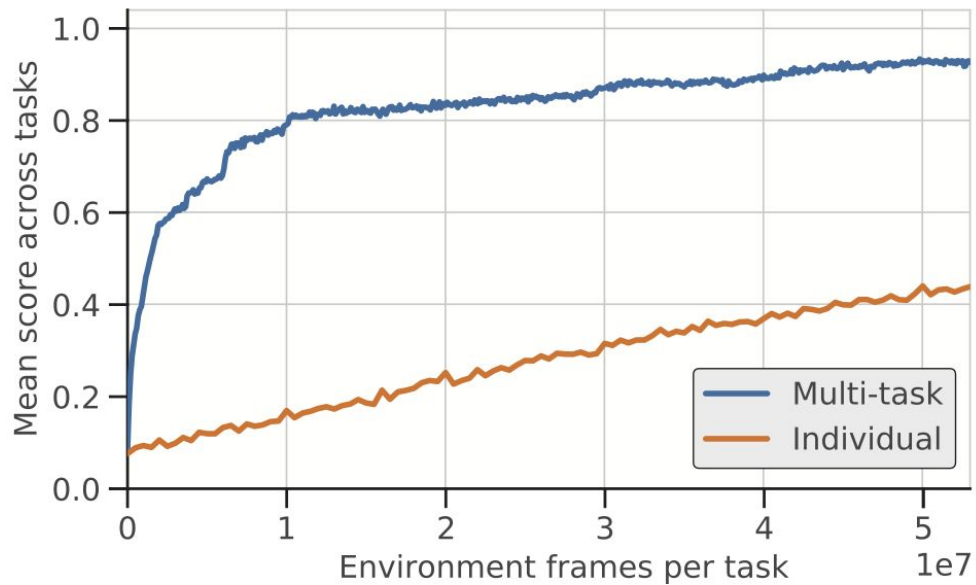
Arrives: 9:01 PM



Data scale was important



Multi-task training was beneficial



DeepMind

Thank you!

**See us at poster
#836**

