Text-based Adventures of the Golovin AI Agent

Bartosz Kostka, Jarosław Kwiecień, Jakub Kowalski, Paweł Rychlikowski

University of Wrocław, Poland

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West of House
You are standing in an open field west of a white house, with a boarded front door.
There is a small mailbox here.
> check mailbox
I don’t know the word "check".
> look into mailbox
The small mailbox is closed.
> open mailbox
Opening the small mailbox reveals a leaflet.
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Interactive fiction (IF)

Brief history
- 1975 – *Adventure*, Will Crowther
- 1979 – Infocom company founded
- 1979 – Zork Implementation Language (ZIL)
- 1980 – *Zork I*, Infocom
- 1989 – Infocom company closed
- 1993 – Inform language, Graham Nelson
- 1995 – first Interactive Fiction Fiction Competition

Z-machine
Virtual machine for simulating games (understanding commands, keeping locations, etc.). Instructions are compiled into Z-code.

Z-code interpreters: Frotz, Rezrov
The Text-Based Adventure AI Competition

- First edition during CIG 2016
- Organized by Tim Atkinson, Hendrik Baier, Tara Copplestone, Sam Devlin, Jerry Swan (University of York)
- One test game, prepared especially for the competition
- (The rules should be released this year)
- Competition won by BYU-Agent – David Wingate, Daniel Ricks, Nancy Fulda, Ben Murdoch (Brigham Young University)
- Winning agent score: 18/100
NATURAL LANGUAGE PROCESSING
Description

You are standing in an open field west of a white house, with a boarded front door.
**Natural Language Toolkit (NLTK)**
- A suite of libraries and programs for symbolic and statistical natural language processing for English written in Python;
- Supports classification, tokenization, stemming, tagging, parsing, and semantic reasoning functionalities.

**word2vec**

![Diagram of word2vec examples]

- Male-Female
- Verb tense
- Country-Capital
THE AGENT
Hey bot, what is your name?

> Your name is Golovin.
Hey bot, what is your name?
> *Your name is Golovin.*
Generating commands

- Standard commands based on the nouns in the game state description and the agent’s inventory
- Computing synonyms, finding similar commands in predefined set
- Scoring each command (synonym similarity, word uniqueness, command popularity, NN model’s weight, ...)
- Roulette wheel command selection
- Blacklisting unsuccessful commands

Battle mode

- Introduced to increase surviving chances
- Triggered by the certain words in the descriptions
- Prevents using standard commands
- Forces to use multiple repetitions of the battle-labeled commands
Algorithm (sketch)

Inventory management
- Interesting objects identified in state descriptions
- Taking objects ordered by NN model’s weight and rarity
- Changes in the inventory clear blacklists

Exploration and mapping
- Allow to visit certain points of interest
- Measuring node curiosity
- Use node identification algorithm

Restarts
- Contest environment allows to restart the game
- Avoid situations that proved to be lethal
- Remember the sequence leading to the best score
Mapping algorithm

Problems
- Same location with multiple descriptions
- Multiple locations with same description

Solution
- (assuming deterministic movement)
- Label each visited location by the description’s first sentence
- Recursively search through the graph and merge the nodes when
  - they have the same label,
  - their adjacent nodes, reached by the same movement command, can be merged.
- Current map is constantly replaced by the minimized one

Usage
- Improves exploration by estimating the number of undiscovered edges
- Allows to reach any before-visited location (using best-known path)
Parameter optimization

Spearmint
Optimizing parameters for black-box model, using Bayesian approach.

Parameters to optimize
- number of synonyms from word2vec
- number of commands used before changing place
- constants used for grading commands
- turning on/off certain features of the algorithm
- . . .

Performance evaluation
- 20 chosen games
- evaluation function:

$$\sum_{\text{game}} \frac{\text{score}}{\text{max\_score}} + (0.2 \text{ if } \text{score} > 0)$$
Experiments
Choosing the language corpus

Score (rescaled in a way that best = 100%)

- Wikipedia
- Books
- Google News
Choosing sources of the commands

Score (rescaled in a way that best = 100%)

WTC
WTCG
WT
WT
W
W
T
T
C
G

W - walkthroughs
T - tutorials
G - descriptions in games
C - commands from routines
Routine R0175, 1 local
Action routine for:
"get out / off / up"
"stand"
"stand up"
"leave noun"
"exit"
JG #05,G12 [TRUE] L0001
JG G12,#008e [TRUE] L0001
JIN G12,"Class" [FALSE] L0002
L0001: CALL_VN R0587 (#04,G12)
Evaluation domain-based mechanisms

Score (rescaled in a way that best = 100%)

- none
- map
- BM
- BM+map
You are in a **closet**. There is a **gun** on the **floor**. Better get it. To **exit**, go east.

### Calculating score
- uniqueness of the word,
- number of words matched,
- popularity of the command,
- cosine distance between the word and the synonym.

Unsuccessful commands go to the blacklist.

### Table

<table>
<thead>
<tr>
<th>action</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>get gun</strong></td>
<td>0.1736</td>
</tr>
<tr>
<td><strong>drop gun</strong></td>
<td>0.1129</td>
</tr>
<tr>
<td><strong>take gun</strong></td>
<td>0.0887</td>
</tr>
<tr>
<td><strong>open closet</strong></td>
<td>0.0557</td>
</tr>
<tr>
<td><strong>examine gun</strong></td>
<td>0.0309</td>
</tr>
<tr>
<td><strong>fire gun</strong></td>
<td>0.0252</td>
</tr>
<tr>
<td><strong>load gun</strong></td>
<td>0.0237</td>
</tr>
<tr>
<td><strong>examine closet</strong></td>
<td>0.0128</td>
</tr>
<tr>
<td><strong>buy gun</strong></td>
<td>0.0042</td>
</tr>
<tr>
<td><strong>sharp gun</strong></td>
<td>0.0006</td>
</tr>
</tbody>
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You are in a shadowy land of low, rolling hills stretching out to the west and south. The land is bordered to the north by a massive stone wall. Ancient and weathered, the wall has crumbled enough at one point to permit passage. A cloaked and hooded person, carrying a sword not unlike your own, is standing blocking the way to the northeast. The hooded figure has a great deal of strength, perhaps matching your own.

> examine figure
There is nothing special to be seen. Your quick reflexes cannot stop the hooded figure’s stroke! You are hit!

> kill figure with sword
The hooded figure is hit with a quick slash! The figure has a light wound which hasn’t affected its seemingly great strength.

> kill figure with sword
You charge, but the hooded figure jumps nimbly aside. The hooded figure stabs nonchalantly with its sword and misses.
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Gameplay example (zork3)

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What can you do with a rock? Affordance extraction via word embeddings; N. Fulda, D. Ricks, B. Murdoch, D. Wingate; IJCAI 2017

- Based on the verb-noun affordances detection
- Wikipedia as the word corpus
- word2vec used to conceptual similarities
- Q-learning to assign scores to state-action pairs

Comparison

- The set of 50 classic IF games, average of 10 tries each
- BYU-Agent:
  - 1000 epochs training
  - 1000 steps in each epoch
  - best score over all epochs
- Golovin
  - 1000 steps with the restarting mechanism
  - last score counts
Comparison with BYU-Agent

Games won

- BUY wins
  - 10.0%

- BYU wins completely
  - 12.0%

- Golovin wins
  - 10.0%

- Golovin wins completely
  - 14.0%
  - non-zero draw
  - 2.0%

- Both agents score zero
  - 52.0%

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Thank you