Contents

Use case: playing video games

The application domain of viash is not limited to just biomedical research. In this tutorial, we will solve one of our pet peeves in a video game called Sid Meier's Civilization.

Background on Civilization

Civilization is a series of six video strategy games where players oversee the development of a civilization, starting from the dawn of civilizations until present times. Not only is the series famous for having defined a lot of the game mechanics in the 4X genre (eXplore, eXpand, eXploit, and eXterminate), it is also frequently associated with the "One More Turn Syndrome".

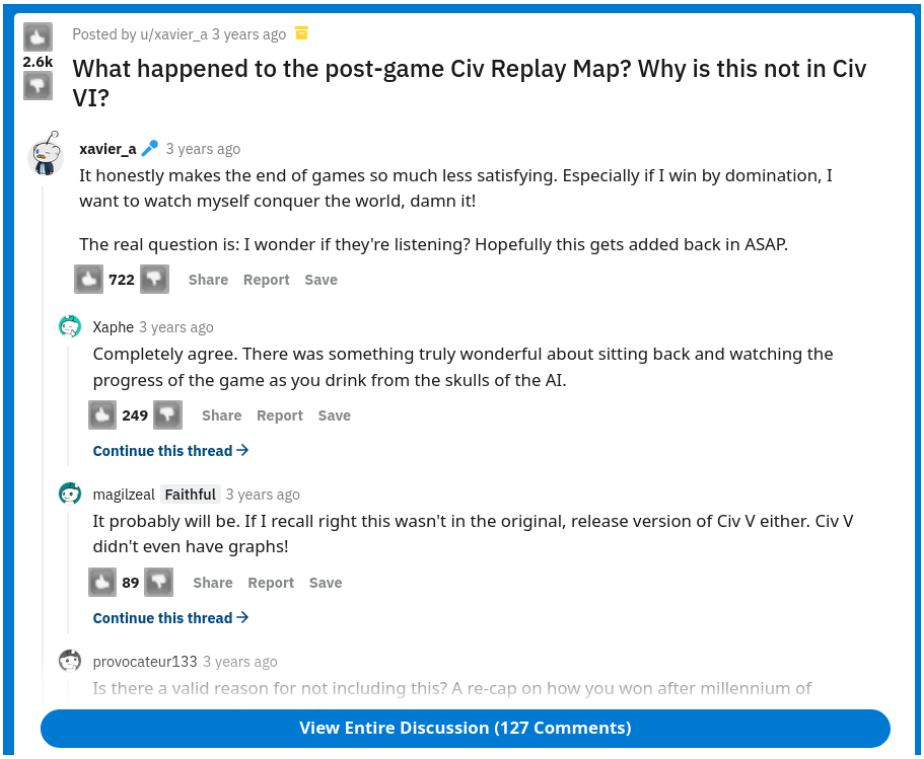
Figure 1: Comic by Mart Virkus, https://arcaderage.co/2016/10/18/civilization-vi/

Post-game replay map

Multiplayer games can take a few hours to finish – anywhere between 2 to 10 hours, depending on who you're playing with. That's why a perfect way of closing a session of Civilization V is by being able to watch a 'postgame map replay' of which owner owned which time at any given point in time.

^

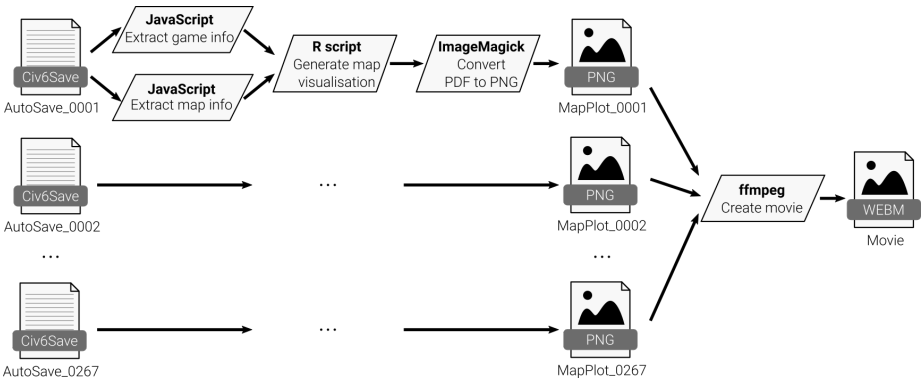
However, for whatever reason, this feature did not make it in Civilization VI. This made a lot of people very angry and been widely regarded as a bad move.



Rendering post-game replay maps

At Data Intuitive, we're all about alleviating people's suffering, so we developed a few scripts for rendering a postgame video for Civilization VI using open-source tools. It works by letting the game automatically creates saves for every turn of the game (called 'autosaves'). An autosave contains all the information to resume the game from that point in time. Since the information that we need is stored in a format, we need scripts to: 1. extract the information from the binary format (in JavaScript), 2. generate a map visualisation (in R), 3. convert all the visualisations into a video (with ImageMagick and ffmpeg).

You can see the general workflow for generating a postgame replay video in the diagram below.



In the next sections, we briefly discuss how each component works, as it will be used later on in the tutorial.

Step 1: Generate input files

Start up Civilization VI and go into the settings menu. You need to configure Civilization VI to create an autosave every turn, and to keep all autosaves as normally only the 10 latest autosaves are kept.

Your first task in this tutorial is to play a game of Civilization VI, yay! See you in a few hours! Don't forget to come back for the remainder of this tutorial!

…

…

Just kidding. We did the fun part and already created autosaves for you. If you check the `data` folder, you will see five autosave files.

```
> ls -l data
total 6592
-rw-rw-r--. 1 rcannood rcannood  612404 Jan 26 10:42 AutoSave_0158.Civ6Save
-rw-rw-r--. 1 rcannood rcannood 1061697 Jan 26 10:42 AutoSave_0159.Civ6Save
-rw-r--r--. 1 rcannood rcannood  107948 Feb  5 00:55 AutoSave_0159.pdf
-rw-r--r--. 1 rcannood rcannood  673420 Feb  5 00:55 AutoSave_0159.png
-rw-r--r--. 1 rcannood rcannood  779029 Feb  4 17:14 AutoSave_0159.tsv
-rw-r--r--. 1 rcannood rcannood    8236 Feb  5 00:55 AutoSave_0159.yaml
-rw-rw-r--. 1 rcannood rcannood 1140352 Jan 26 10:42 AutoSave_0160.Civ6Save
-rw-rw-r--. 1 rcannood rcannood 1164860 Jan 26 10:42 AutoSave_0161.Civ6Save
-rw-rw-r--. 1 rcannood rcannood 1179409 Jan 26 10:42 AutoSave_0162.Civ6Save
```

Step 2, `parse_header`: Extract game info

So how do we parse the binary Civ6Save data format? Luckily, by the miracles of open-source software development, GitHub users Mike "mrosack" Rosack and Tuomas "iqqmuT" Jaakola already developed a tool for extracting which players are playing which civilizations. You can install their software by running the following command.

Note that you do not need to install these commands yourself, as we will see in a later part of the tutorial how to do this more easily with viash!

```
> npm install civ6-save-parser
npm WARN saveError ENOENT: no such file or directory, open '<...>/workspace/di/viash_workshop_1/pac
npm notice created a lockfile as package-lock.json. You should commit this file.
npm WARN enoent ENOENT: no such file or directory, open '<...>/workspace/di/viash_workshop_1/packag
npm WARN viash_workshop_1 No description
npm WARN viash_workshop_1 No repository field.
npm WARN viash_workshop_1 No README data
npm WARN viash_workshop_1 No license field.

+ civ6-save-parser@1.1.14
added 7 packages from 8 contributors and audited 7 packages in 2.378s
found 0 vulnerabilities
```

You can view which players are playing the game by running the following command:

```
> node node_modules/civ6-save-parser/index.js data/AutoSave_0159.Civ6Save --simple | head -20
{
  ACTORS: [
    {
      START_ACTOR: 4159575459,
      ACTOR_NAME: 'CIVILIZATION_FREE_CITIES',
      ACTOR_TYPE: 'CIVILIZATION_LEVEL_FREE_CITIES',
      ACTOR_AI_HUMAN: 1,
      LEADER_NAME: 'LEADER_FREE_CITIES'
    },
```

```
    {
      SLOT_HEADER: 19,
      ACTOR_NAME: 'CIVILIZATION_ARMAGH',
      ACTOR_TYPE: 'CIVILIZATION_LEVEL_CITY_STATE',
      ACTOR_AI_HUMAN: 1,
      LEADER_NAME: 'LEADER_MINOR_CIV_ARMAGH'
    },
    {
      START_ACTOR: 4058321742,
      ACTOR_NAME: 'CIVILIZATION_BOLOGNA',
      ACTOR_TYPE: 'CIVILIZATION_LEVEL_CITY_STATE',
```

The output is a json file, which you save as follows.

```
#!/bin/bash

par_input=data/AutoSave_0159.Civ6Save
par_output=data/AutoSave_0159.yaml

node node_modules/civ6-save-parser/index.js "$par_input" --simple > "$par_output"
```

Step 3, `parse_map`: Extract map info

Alright, so we know which games are playing the game, but which tiles do they own? As there are no ready to use npm packages available to do this specific task, we had to write this functionality in JavaScript ourselves. The scripts `helper.js` and `script.js` are based on work by Lucien "lucienmaloney" Maloney on GitHub.

Some helper functions are defined in `helper.js` (some code is omitted for the sake of clarity). The `decompress()` function reads in the binary data, while the `savetomap()` function responsible is for parsing the relevant data about each time in a tabular format.

```
const zlib = require('zlib');

/**
 * Output a decompressed buffer from the primary zlib zip of the .Civ6Save file
 * @param {Buffer} savefile
 * @return {Buffer} decompressed
 */
function decompress(savefile) {
  // ... omitted for the sake of clarity ...
}

/**
 * Convert compressed tile data in .Civ6Save file into json format
 * @param {buffer} savefile
 * @return {object} tiles
 */
```

```
function savetomap(savefile) {
  // ... omitted for the sake of clarity ...
}

module.exports = {
  decompress,
  savetomap
}
```

Reading in the map data and saving it as a tsv (tab-separated values) table can be done by executing the scropt `script.js`.

```
let par = {
  'input': 'data/AutoSave_0159.Civ6Save',
  'output': 'data/AutoSave_0159.tsv'
}

// read helper libraries & functions
const fs = require("fs");
const helper = require("helper.js");

// read data from file
const json = helper.savetomap(fs.readFileSync(par["input"]));

// convert to tsv
const headers = Object.keys(json.tiles[0]);
const header = headers.join("\t") + "\n";
const lines = json.tiles.map(o => {
  return Object.values(o).map(b => JSON.stringify(b)).join("\t") + "\n";
});
const tsvLines = header + lines.join('')

// save to file
fs.writeFileSync(par["output"], tsvLines);
```

Note that at this stage, the imported data looks very raw. These are the first 10 rows and 10 columns of the generated tsv.

x	y	hex_location	travel_regions	connected_landmass	landmass	terrain	feature	natural_wonder	continent
0	0	1429433	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295
1	0	1429488	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295
2	0	1429543	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295
3	0	1429598	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295
4	0	1429653	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295
5	0	1429708	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295
6	0	1429763	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295
7	0	1429818	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295
8	0	1429873	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295
9	0	1429928	65536	65536	4294967295	4294967295	4294967295	4294967295	4294967295

Step 4, `plot_map`: Generate map visualisation

With both the game metadata in the yaml file and the map information in the tsv file, we can finally go ahead and generate our first map visualisation. The map is being generated with a software package called 'ggplot2' in R, but first we need to download all the required software for it. Provided that you already have R installed, we need to run the following code to install all of the dependencies. Setup:

```
install.packages(c("ggforce", "yaml", "bit64", "ggnewscale", "cowplot", "devtools"))
devtools::install("rcannood/civ6saves")
```

Some helper functions are defined in `helper.R` (some code is omitted for the sake of clarity). The `read_header()` and `read_map()` functions respectively read in the yaml and tsv files outputted in the previous steps. The `make_map_plot()` function uses those two data objects and generates a map view of the data provided.

```
library(tidyverse)
requireNamespace("ggforce", quietly = TRUE)
requireNamespace("civ6saves", quietly = TRUE)
requireNamespace("bit64", quietly = TRUE)
requireNamespace("yaml", quietly = TRUE)
requireNamespace("ggnewscale", quietly = TRUE)

read_header <- function(yaml_file) {
  # read yaml file
  # ... omitted for the sake of clarity ...
}

read_map <- function(tsv_file) {
  # read tsv file
  # ... omitted for the sake of clarity ...
}

make_map_plot <- function(game_data, map_data) {
  # plot map with ggplot2
  # ... omitted for the sake of clarity ...
}
```

With `script.R` we tie all data inputs and helper funcies to generate a PDF file of turn 159 of the game we played for you.

```
library(tidyverse)
library(cowplot)

source("helper.R")

par <- list(
  yaml = "data/AutoSave_0159.yaml",
  tsv = "data/AutoSave_0159.tsv",
  output = "data/AutoSave_0159.pdf"
```

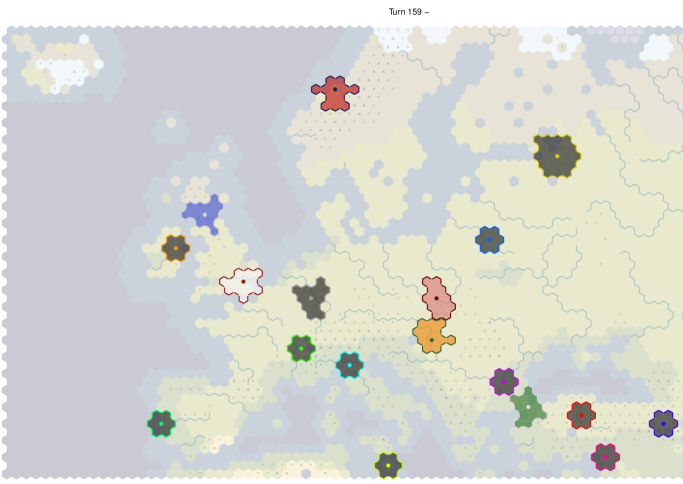
```
)

# read data
game_data <- read_header(par$yaml)
map_data <- read_map(par$tsv)

# make visualisation
g <- make_map_plot(game_data, map_data)

# save map to file
gleg <- cowplot::get_legend(g)
gnoleg <- g + theme(legend.position = "none")
gout <- cowplot::plot_grid(gnoleg, gleg, rel_widths = c(8, 1))
ggsave(par$output, gout, width = 24, height = 13)
```

This is what the generated PDF file looks like.



Step 5, `convert_plot`: Convert PDF to PNG

Setup:

```
sudo apt-get install imagemagick
```

Convert:

```
#!/bin/bash

par_input=data/AutoSave_0159.pdf
par_output=data/AutoSave_0159.png

convert "$par_input" -flatten "$par_output"
```

Step 6, `combine_plots`: Create movie

Setup:

```
sudo apt-get install ffmpeg
```

Convert:

```
#!/bin/bash

par_input="data/AutoSave_0159.png|data/AutoSave_0002.png|..."
par_output="data/Movie.webm"

ffmpeg -framerate 4 -i "concat:$par_input" -c:v libvpx-vp9 -pix_fmt yuva420p -y "$par_output"
```

Enter viash, stage left

While we at Data Intuitive can now happily churn out postgame videos of all of our Civilization VI, installing the requirements on a different system is a hassle. Because of the complicated software requirements, and because of its pipeline-like workflow, this application is serves as a perfect example of why and how to use viash.