Antarctic Futures: Game-based Simulation of Environmental Loss and Preparedness *

Liam Magee[1], Andrea Pollio[2], and Marina Khan[1]

[1]Institute for Culture and Society, Western Sydney University
[2]Future Urban Legacy Lab, Polytechnic of Turin

June 2020

Contents

Abstract

The game *Antarctic Futures* aims to provoke discussion and dialogue about various ways to address pressing environmental challenges impacting on the Antarctic continent and the planet. It uses an equation-based, partly stochastic simulation which, without player interaction, results in global catastrophe by the year 2070. This article introduces the game, describes the model which drives the simulation, as well as the effects of player interaction. Based on logs of player interation, it analyses strategies

*This article was developed as part of *Antarctic Cities and the Global Commons: Rethinking the Gateways* (LP160100210), funded by the Australian Research Council and project partners Hobart City Council; Department of State Growth; University of Canterbury, Christchurch; Christchurch City Council; Chilean Antarctic Institute; University of Magallanes.

used by players in early iterations of the game, illustrating how complex scientific models can be adapted to engage human participants and act as social science research instruments. We conclude with considerations of refinements to the model, as well as prospects for adapting the game to various pedagogical and other 'serious' game settings.

1 Introduction: Simulations in Serious Games

1.1 Background

As the aim for the game was to communicate the complexity of policies given constraints, scientific and otherwise, we chose to develop a real-time strategy (RTS) simulation game.

One popular class of simulation game uses a two-dimensional world; most often a fantastic one, but sometimes also a some representation of the actual world. *SimCity*, *Civilization*, *Age of Empires* and *Command and onquer* are well-known examples.

A sub-class of the simulation genre, RTS games incorporate several common features *GameSpot Presents* 2011: a continuous progression through the game – the 'real-time' element; a set of decisions that together form a 'strategy'; an explicit objective, usually to defeat a human or computer-driven enemy; and constraints, often in the form of limited resources which need to be deployed with care to accomplish goals (building defences, strengthening armies and so on). Such games differ from 'god-mode' games such as *SimCity*, where the player has constraints but no adversarial conditions to combat *GameSpot Presents* 2011.

One variation of RTS involves pandemics, plagues or viruses. Adapted from a board game of the same name, titles such as *Pandemic* *Pandemic* 2020, its successor *Pandemic II* (released in 2008) and a derivative and highly popular game *Plague Inc* (released in 2012) *Pandemic* 2020 ask the player to adapt a virus or bacteria, with the goal of infecting the world's human population. As time unfolds, the player gains resources, mutates their virus and pre-empts human efforts to find a cure.

Such viral simulation games have been popular during the COVID-19 crisis in 2020, to such a degree that Pandemic II has seen a resurgence despite its reliance upon the aging *Flash* platform *An old flash computer game is getting a 2nd life because of its eerie similarities to the coronavirus outbreak, and its website's CEO says it has too much of an 'educational value' to shut it down — Business Insider* 2020, and the publisher of Plague Inc needed to issue warnings not to rely upon its realistic but fictitious modelling of viral spread *Video game company urges users to seek information about coronavirus from official sources, not its game - CNN* 2020.

Their combination of compelling gameplay, global visualisation and an approximation of scientific rigour makes this sub-genre an inter

...

2 Antarctic Futures Model

The model assumes a single root entity called *World*.

The world has multiple instances of a *Country* class. The class is derived from the definitions from Natural Earth Data.

At each tick of the simulation, the model generates two output variables for each country, $loss$, a proxy of environmental and other losses, and $preparedness$, a measure of or proxy for resilience, sustainability and other factors.

2.1 Calculating Loss

For each country, C_i, calculation of loss depends upon two properties, Inc, income (using income group designations supplied by the World Bank), and Pop, estimated population.

A *rateOfLoss*, $rateOfLoss$, variable is set, which applies that rate for each tick of *time*, T, to each country C_i, starting from 0.

$$rateOfLoss = rateOfLoss * (0.5 + E) + 1.0 \tag{1}$$

The rate is adjusted by a random error term E, as shown in equation 1, and added to 1.0, for convenience as a multiplier.

$$rateOfLoss = \frac{1.0 + 0.1 * preparedness}{rateOfLoss} \tag{2}$$

To account for resilience, this adjusted rate of loss is divided by the country's current preparedness level, $preparedness$, as shown in 2. An arbitrary constant of 0.1 is used to moderate the impact of $preparedness$.

$$rateOfLoss = rateOfLoss * \sum_{j=1}^{n}(1.0 + crisis_j * \sqrt{\frac{loss_t}{worldLoss_t}}) \tag{3}$$

For each current crisis, $crisis_j$, the rate of loss is further adjusted by the loss (¿ 1.0) or gain (¡ 1.0) represented by the crisis. To limit the possibility of particular countries deviating greatly from world mean, this adjustment is dampened, by the square root of quotient of the country, $loss_t$, and world loss, $worldLoss_t$.

$$decay = e^{|1-((loss_t - inflection)/inflection)|} \tag{4}$$

The game has an optional setting that includes a sigmoidal decay loss function, i.e. (1) a slow initial uptake of losses, followed by (2) a fat rate of increase through the middle of the simulation, and (3) a slow-down towards the end, to allow the player some opportunity to recover.

The sigmoidal decay function, shown in 4, takes a bounded percentile value (0-100) – in this case current country loss, $loss$ – and an inflection point,

$inflection$ (also 0-100), and return a value between e and $1/e$ (or approaching 0, with a change of the $inflection$ parameter).

Changes to the inflection point (e.g. nearing zero or 100) allow the function to act as a cumulative distribution function for a Poisson-like distribution, and accordingly, to model loss as progressively decreasing or increasing.

$$rateOfLoss = 1.0 + (rateOfLoss - 1.0) * decay \tag{5}$$

With the sigmoidal option turned on, the rate of loss (RoL) is further adjusted, as shown in 5.

$$loss_{t+1} = max(0, min(loss_t * rateOfLoss, 100)) \tag{6}$$

Once all adjustments are applied, the rate of loss is applied to the current loss, $loss_t$, as shown in 7. The result is clamped to the range $[0, 100]$.

$$worldLoss = \frac{\sum_{i=1}^{n} loss_i}{n} \tag{7}$$

Finally, world or total loss is the (unweighted) average of all country losses.

Preparedness

...

Calculation

3 Game Implementation of the Model

The Antarctic Futures game model is build around a *World* class.

When the game initialises, it creates a single instance (or singleton) of the World class.

1 shows a screenshot of the game.

4 Discussion

Challenges of modelling large-scale catastrophes have been widely discussed in relation to economic crises such as the Global Financial Crisis, climate change / global warming, and COVID-19 Squazzoni et al. 2020.

5 Conclusion

...

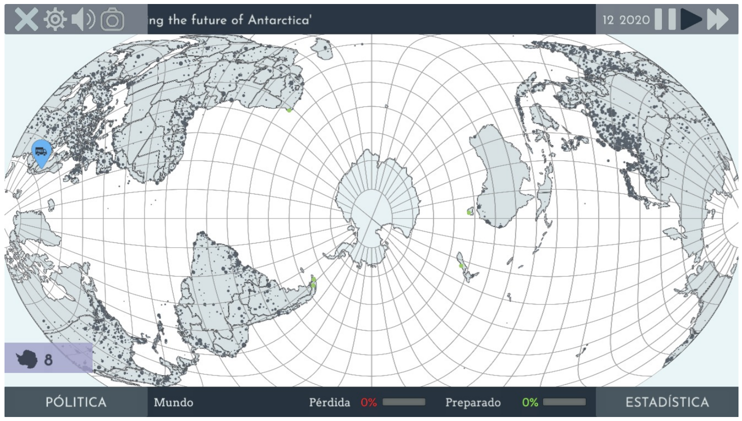

Figure 1: Antarctic Futures Screenshot

References

An old flash computer game is getting a 2nd life because of its eerie similarities to the coronavirus outbreak, and its website's CEO says it has too much of an 'educational value' to shut it down — Business Insider (2020). URL: https://www.businessinsider.com.au/coronavirus-pandemic-2-computer-game-second-life-amid-outbreak-2020-3?r=US&IR=T (visited on 05/29/2020) (cit. on p. 2).

GameSpot Presents (Apr. 27, 2011). *GameSpot Presents: A History of Real-Time Strategy Games*. URL: https://web.archive.org/web/20110427052656/http://gamespot.com/gamespot/features/all/real_time/ (visited on 05/29/2020) (cit. on p. 2).

Pandemic (2020). URL: https://www.asmodee-digital.com/en/pandemic/ (visited on 05/29/2020) (cit. on p. 2).

Pandemic (2020). Plague Inc. Wiki. Library Catalog: plagueinc.fandom.com. URL: https://plagueinc.fandom.com/wiki/Pandemic (visited on 05/29/2020) (cit. on p. 2).

Squazzoni, Flaminio et al. (2020). "Computational Models That Matter During a Global Pandemic Outbreak: A Call to Action". In: *Journal of Artificial Societies and Social Simulation* 23.2, p. 10. ISSN: 1460-7425. DOI: 10.18564/jasss.4298. URL: http://jasss.soc.surrey.ac.uk/23/2/10.html (cit. on p. 4).

Video game company urges users to seek information about coronavirus from official sources, not its game - CNN (2020). URL: https://edition.cnn.com/2020/01/26/tech/plague-coronavirus-game-warning/index.html (visited on 05/29/2020) (cit. on p. 2).