Modelling Routinization in Games - An Information Theory Approach

Information Theory, Routinization, Markov Chains, Games

Simon Wallner
Vienna UT
me@simonwallner.at

Michael Hecher
Vienna UT
hecher@cg.tuwien.ac.at

Martin Pichlmair
ITU Copenhagen
mpic@itu.dk

Michael Wimmer
Vienna UT
wimmer@cg.tuwien.ac.at

FAKULTÄT FÜR !NFORMATIK Faculty of Informatics

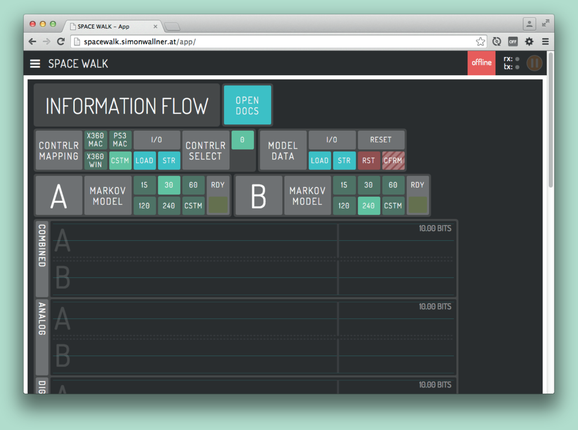
IT UNIVERSITY OF COPENHAGEN

Many processes in our everyday lives are performed without conscious effort – like picking up the phone or shifting gears in a car. Elements of games are often repetitive and thus lend themselves to routinization via practice. Based on prior research in activity theory and practice theory, our definition of routinization is that routinized play is individual, repeatable, self-similar and appears proficient. Using Markov chains and information theory as tools, we can make this process measurable. This allows us to see where and how routinization happens as well as its implications.

Instead of measuring routinization directly, we model routinization with discrete-time, discrete-space Markov chains and compare them to the current user input. The difference is measured by computing its information content. Information content is a measure of how surprising a specific event is. As an example, consider learning that a friend is awaiting a baby. Depending on the person, this might be surprising on its own, but now consider learning that this person is actually awaiting twins or even triplets. The probability of that event is lower and thus the information gained by learning about it is higher.

Based on results from our exploratory pre study and our definition of routinized play we arrive at our working hypothesis: **Discrete-time, discrete-space Markov chains can be used as a general model for routinization of specific gameplay elements.**

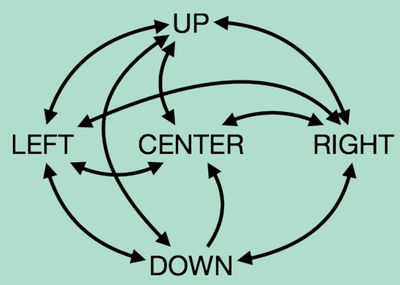
In our upcoming study we are going to generalize our initial findings to a larger number of players and further analyse the impact of the modelling parameters. Applying information theory to formal models of play is a promising proposition and with our work we hope to have taken the first step into this new field.



Space Walk

For the purpose of our study, we created “Space Walk” a web-based, real time telemetry and analysis platform. It uses modern web technology to analyse and visualise data and to provide rich user interfaces, and it is modularised for easy extension and customization.

Space Walk is developed under the permissive MIT open source license and publicly available at http://spacewalk.simonwallner.at.



Markov Model

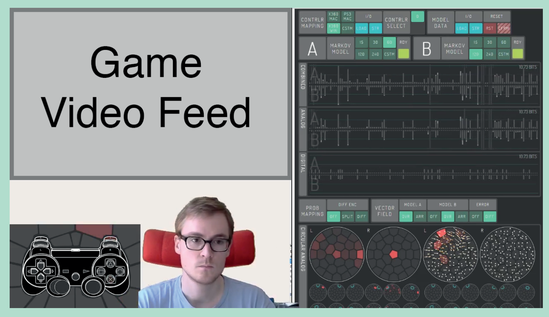
Markov chains are used as a general model for routinization. They are very general and only require a small set of a priori assumptions. They are not black boxes, and can easily be understood and visualized to gain further insights.

Markov chains can be trained on-the-fly and since routinized actions are expected to be self similar, the parameters (i.e. the edge weights) are expected to converge to a stable configuration in the face of routinized play.

Information Theory

We use information theory to assess how well the observed data fits our models by measuring the resulting information content of the user’s input. Information content (also called ’self-Information’ or ’surprisal’) describes how much information is gained from having observed an event. The information content I of an event x is solely dependent on its a posteriori probability $p(x)$ and can be calculated with the above formula. The more predictable an event is, the less information it carries and vice versa.

$$I(x) = \log_2 \left(\frac{1}{p(x)} \right) bits$$



Preliminary Results

Our hypothesis is based on results of an exploratory pilot study with various games from different genres. A combined video recording of the game, a video feed of the player, a direct visualization of the game controller and the computed model error has been recorded during the test session. A post-hoc analysis of the data showed different patterns emerging from different games and gameplay elements. By using the above described models and our definition of routinized play we observed the routinization within the individual levels in Super Meat Boy, a 2D action platformer game. The model dynamically adapted to the routinization of the player, which resulted in a good overall model fit.