Abstract: This paper presents a procedural generation method that creates visually attractive levels for the Angry Birds game. Besides being an immensely popular mobile game, Angry Birds has recently become a test bed for various artificial intelligence technologies. We propose a new approach for procedurally generating Angry Birds levels using Chinese style and Japanese style building structures. A conducted experiment confirms the effectiveness of our approach with statistical significance.

Keywords: Procedural Content Generation, Angry Birds, Game Levels, Chinese Style, Japanese Style

1. Introduction

This paper discusses how aesthetic Angry Birds level can be generated procedurally. In our proposed method, Angry Birds level is created by inputting Chinese style or Japanese style structures into generation rules written in our proposed building constructive grammar. The generated Angry Birds level not only mimics Chinese and Japanese architectural styles, but also combines and mixes the features of both styles into a aesthetic structure. A survey was conducted to test if our approach could create levels using Chinese and Japanese architectural features that are recognizable to players. This research used the Angry Birds clone developed by Ferreira and Toledo (2014), which can be downloaded from GitHub1.

2. Related Research

2.1. Generating buildings with model library

In existing research, generating Asian style 3D buildings using a model library and pre-defined parameters was conducted (Teoh, 2009). However, in order to generate a building with a desired style, the user has to set the parameters manually.

2.2. Video Game Description Language (VGDL)

VGDL (Ebner et al., 2013) is a language for describing game maps and game rules. VGDL is acclaimed for its readability, simplicity and scalability, and is being used to generate a wide range of games for the General Video Game AI Competition. However, the current version of VGDL does not support gravity or physics simulation, resulting in it being an unsuitable language for generating realistic buildings, which are subjected to physical constraints.

3. Proposed Method

To overcome the limits of VGDL, we propose a grammar called 2D Building Construction Grammar (2D-BCG). A level can be defined by a set of 2D-BCG rules, and rendered using structures with different styles. As a result, a structure with Chinese or Japanese architectural style can be generated automatically.

3.1. 2D Building Construction Grammar

2D-BCG is used for describing a building structure. In this set of rules, a building is divided into 3 parts: base, main and roofs, from bottom to top. Building is formed by 7 elements, including wall, floor, beam, window, door, roof and toproof (Fig. 1 left).

The 2D-BCG is written in Backus-Naur Form as shown below. In the following, variables enclosed in angle brackets (<> are non-terminal symbols, while variables not enclosed are terminal symbols. Non-terminal symbols on the left hand side of a "::=" mark can be expanded to symbols on the right hand side. The "|" mark means selection; a symbol can be expanded into any symbols connected by the "|" mark.

\[
\text{<building>} ::= \text{<base>} <\text{main}> <\text{roofs}>
\]
\[
\text{<base>} ::= \text{wall floor} | \text{wall} | \text{floor}
\]
\[
\text{<main>} ::= \text{beam <mainlist>} \text{ beam}
\]
\[
\text{<mainlist>} ::= \text{window} | \text{door} | \text{roof} \text{ <mainlist}> | \text{mainlist}
\]
\[
\text{<roofs>} ::= \text{beam <mainlist>}
\]
\[
\text{<rooflist>} ::= \text{roof} | \text{roof <rooflist>}
\]
\[
\text{<rooflist>} ::= \text{roof} | \text{roof <rooflist>}
\]

3.2. Various Styles

Architectural styles in this study imitate Chinese and Japanese building styles in real world. Chinese style and Japanese style share similar beam, floor and wall, but their toproof, roof, window and door are different from each other. In particular, in our work, there is only 1 type of beam shared by both Chinese style and Japanese style.

3.3. An Example of Rules and Generated Levels

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1https://github.com/lucasnfe/AngryBirdsCover (last accessed on Feb 7, 2016)
Below is an example of a rule written in 2D-BCG. A level generated by the example rule and a real building similar to the generated building are shown in Figure 1.

\[
\text{<building>} ::= \text{<base>} \text{<main>} \text{<roofs>}
\]
\[
\text{<base>} ::= \text{wall floor}
\]
\[
\text{<main>} ::= \text{beam window window beam window door window beam window beam window beam}
\]
\[
\text{<roofs>} ::= \text{roof roof toproof}
\]

To maintain consistency within the structure of the generated building, the same style is used for all parts of the same element in the structure. For example, if the building has two windows, the same style will be selected and applied to both windows.

### 3.4. Generated Levels

While 2D-BCG can generate infinite sets of rules, in this study only five rules (Table 1) were considered. All rules were created based on the structures of several historical buildings in China and Japan. The number of models available for each element is shown in Table 2.

| Rule | Suitable for | Chinese-style | Japanese-style | Japanese-style |
|------|--------------|---------------|----------------|---------------|
| Base1 | wall floor | 3 3 3 | 3 3 3 | 3 3 3 |
| Base2 | wall floor | 3 3 3 | 3 3 3 | 3 3 3 |

The number of all Chinese style, Japanese style and composite style levels that can be generated by our rules is 567, 540, and 10125. There were 10 rules for the composite style, which combines rules of both Chinese style and Japanese style. It shows that even with a small number of rules and models, a vast diversity of levels can be created.

### 4. Experiment

A survey was conducted to assess the visual design of the generated levels. The experiment concerned 25 voluntary participants, among which 23 were male and 2 were female, and 23 were within the age range 18 – 24 and the rest were within 25 – 34. Each subject was presented generated levels and was asked to identify whether the building is a Chinese or Japanese style. The nationalities of our participants included Chinese(1), French(2), Japanese(19), Thai(1), Vietnamese(1), and Other(1).

### 5. Conclusions

This paper presented a new approach for generating a visually attractive building that imitates Chinese style, Japanese style or a composite style architecture in the Angry Birds game. A conducted experiment confirmed that levels that mimic Chinese style or Japanese style architecture can be generated procedurally. In our future study, other architectural styles will be considered.

### References

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