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It was a pleasure to read the thesis of Mgr. Jan Beneš. The main aim of the research was to investigate realism in procedurally generated datasets in computer graphics, a topical subject that so far for some reason did not attract much needed attention. The research on this topic is timely.

Procedural modelling is one of the principal lines of research in computer graphics, and it has been subject of research of a large number of research groups and companies. However, the inherent nature of procedural modelling causes the resulting models to potentially include less realistic appearance, especially if intended to mimic a real-world setting.

The thesis contributes to the field by leading a thorough discussion on realism in both computer graphics and procedural modelling and bringing new concepts such as nomenclature, quantifying and measuring realism in procedural modelling, and after focusing on procedurally generated buildings – introducing a study to evaluate their perceived realism. A final contribution is developing a method for generating urban road networks that adhere to the introduced concepts of realism.

The research is novel, well executed, and it is worth a PhD degree. It is without a doubt that Jan mastered the topic and has tackled it properly.

The thesis as a product of the research is nicely structured, the text is grammatically correct and clear, and the accompanying visuals are of high quality. Much of the thesis is accessible also to readers outside the field of computer graphics. Even though at first the chapters may sound less related, the flow between them is nicely executed and they come together in a cohesive piece.

The candidate has published papers supporting this thesis in the reputable outlet of Computer Graphics Forum. Having two papers in a top journal is an encouraging fact that the research has been assessed by experts in the field and that it is of relevance to the international computer graphics community. Moreover, the candidate has carried out a part of the work at ESRI R&D (one of the prominent organisations in this domain) and Yale University.

The research is carried out in four domains:

1. Realism in computer graphics
2. Realism in procedural modelling
3. Realism of procedurally generated buildings
4. Procedural generation of urban road networks

which are reflected in four core chapters (Chapters 2, 3, 4, and 5).

Even though procedural modelling is part of computer graphics, as an non computer graphics specialist I initially found it interesting that the candidate has made a decision to split realism between CG and PM (topics 1. and 2.). After reading the chapters, I second that path.

A more detailed review per core chapter follows.

Chapter 2 (Realism) identifies three elements of realism (geometry, material appearance and rendering), it analyses the definitions of realism in existing literature in computer graphics, introduces concepts related to realism, and analyses the approaches that current literature uses for validation and investigation of realism. For a large part the chapter is a literature review, which is well structured and novel contributing to the field.

The elements of realism are largely independent of each other, and only with the presence of all of them a scene can be considered fully realistic.

The chapter makes a case for distinguishing different types of realism, e.g. visual realism and functional realism. The examples that are given for each case (e.g. an image of driving in London on the ‘wrong’ side) are convincing and easy to understand. Furthermore, the chapter gives also a temporal aspect to understand the topic and give an impression that criteria may change over time (i.e. games from 25 years ago have been considered highly realistic, but now they are clearly not anymore).

The section on photorealism focuses on the aspect of realism in photography, defining two types of photography (measurement photography and common photography).

Finally, the evaluation of realism in rendering is discussed, including the role of neural networks in realism.

Chapter 3 (Realism in Procedural Modeling) dives more into the topic, continuing from Chapter 2, which is an uncharted domain which this research seeks to explore.

First, an overview of procedural modeling is given, introducing the reader to the topic, use cases, approaches, terminology, etc. in the context of realism (e.g. full models aim for full realism). Second, the chapter proceeds onto elaborating on the characteristics of procedural rules, again geared towards realism. The third part of the chapter moves on the key topic of evaluating realism in procedurally generated models. It introduces three principles related to the topic, e.g. evaluation should be done on each new procedural rule rather than procedural method.

Chapter 4 (Realism of Architectural Procedural Models) explores realism in
procedurally generated buildings. Mainly, the chapter investigates the role of
details in the perception of realism, and the related qualitative factors, in the
context of procedurally modelled buildings. Buildings are the most prominent
feature of the built environment, and it’s not a surprise that procedural modelling
of buildings has been quite in focus of the computer graphics community. A user-
survey including dozens of participants using relevant data has been conducted.
One of the notable results is that fine detail is not alone in driving realism, but
course detail and structure at various scales play a major role as well. Further -
repeated features appear not to be important in achieving realism.

Chapter 5 (Procedural Generation of Urban Road Networks) is the final contri-
bution of the research, describing the design and implementation of a method to
procedurally generate roads in and around the urban setting. However, while
it demonstrates that the candidate is capable of building his own procedural
technique, a downside of this chapter is that it does not stick well with the
previous ones as it does not put realism entirely in focus as it was announced in
Chapter 1. The chapter builds only partially on top of the previous chapters
(i.e. plausibility). Nevertheless, it’s a valuable scientific contribution, and it’s
a welcoming change from the universal focus on buildings, which seem to have
been subject of most research in procedural modelling, and it is to be expected
that all the research during a PhD cannot fit perfectly together like a novel.

Overall I am positive about this research and the submitted thesis. Further, the
thesis suggests that the candidate is well aware of the literature and previous
work in the field, and the candidate has demonstrated that he is also able to
map out a future research agenda and roadmap for future work.

I believe that the thesis provides evidence that its author is capable of independent
research work and I recommend it for the defense.

Filip Biljecki