Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Engineering
Department of Structural Engineering

Hanne Overrein

Stigmergy in Construction

Master's thesis in Engineering and ICT
Supervisor: Tor Guttorm Syvertsen
June 2019

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Stigmergy in Construction

Stigmergi i Byggebransjen

BY:

Hanne Overrein

SUMMARY:

This master thesis is investigating stigmergy as a coordination mechanism. It looks at stigmergy in insects, in human behaviour, and peer production. The thesis also examines the coordination and organisation of the construction industry and elsewhere. Lastly, the two are joined into looking at stigmergy in the construction industry. It investigates the opportunities of stigmergy in construction. The thesis also discusses obstacles to stigmergic collaboration in construction. The thesis is published as a website. This report is prepared as a required paper document to the Department of Structural Engineering, NTNU. It discusses some of the design aspects of the website and gives the motivation for submitting the thesis as a website.

RESPONSIBLE TEACHER: Tor Guttorm Syvertsen

SUPERVISOR: Tor Guttorm Syvertsen

CARRIED OUT AT: Department of Structural Engineering

MASTER THESIS 2019

for

Stud. techn. Hanne Overrein

Stigmergy in Construction

Background

Natural phenomena have given inspiration to several scientific fields opening for new ideas and inventions. Stigmergy is one such mechanism that was firstly observed in tiny termites. This phenomenon has later been studied, and the coordination mechanism is seen in several different species. The way of indirect coordination has made its way to several other fields such as computer science and robotics.

The idea

The idea is to look further into what stigmergy is and different cases where it is observed. Further work will look at how it can be related to coordination in the construction industry. The thesis will be a continuation of the work done in the project thesis *Stigmergy in Construction* from autumn 2018.

Scope of Work

The scope of work is to investigate the different occurrences of stigmergic coordination such as in ants, on Wikipedia and in construction. The thesis will briefly look at construction management and characteristics of the construction industry. The work will also look to other industries for inspiration.

The work will be presented on a website made in Wix.com. The website will be designed to communicate the thesis contents easily. A part of the work will be to explore the opportunities of presenting a thesis project digitally on a website.

Deliverables

The master thesis will be presented as a website. The website will be delivered through a link, as part of a written report. The submission will be handed in, to the Department of Structural Engineering by 11. June 2019.

Supervised by Professor Tor G. Syvertsen.

Summary

This master thesis is investigating stigmergy as a coordination mechanism. It looks at stigmergy in insects, in human behaviour, and peer production. The thesis also examines the coordination and organisation of the construction industry and elsewhere. Lastly, the two are joined into looking at stigmergy in the construction industry. It investigates the opportunities of stigmergy in construction. The thesis also discusses obstacles to stigmergic collaboration in construction. The thesis is published as a website. This report is prepared as a required paper document to the Department of Structural Engineering, NTNU. It discusses some of the design aspects of the website and gives the motivation for submitting the thesis as a website.

Preface

The Master Thesis is the final part of the Advanced Engineering program of Engineering and ICT at the Norwegian University of Technology. The thesis was written for the Department of Structural Engineering over 20 weeks in the spring semester of 2019.

The thesis is a prolongation of the work done in a literature study from autumn 2018. The literature study, *Stigmergy in Construction*, mainly investigated stigmergy. This provided a basis for the further studies and linking stigmergy to construction management in this master thesis.

Professor Tor Guttorm Syvertsen has supervised the work of the project thesis and the master thesis. I want to thank Prof. Syvertsen for his invaluable help and engagement in the thesis work. His feedback and meaningful discussion have been highly appreciated.

Table of Contents

1 About the Website

The main delivery of the thesis is a website. The website has been built using a website builder to convey the contents of the master thesis “Stigmergy in Construction”.

The website might be browsed in the order of each's preference. However, there is a suggested reading sequence. This sequence is the order in which the structure of the navigation on the website is laid out. It can be followed by navigating the top menu from left to right. Each page includes buttons suggesting which page to read next or which page was the previous one, for more straightforward navigation of the suggested order.

The website is published to the following address.

https://hanneoverrein.wixsite.com/stigmergy

2 The Motivation for the Website

Delivering a thesis as a website was suggested by the supervisor Prof. Syvertsen for the project thesis of autumn 2018. Several advantages were associated with this submission medium, which leads to the final submission of the master thesis as a website.

A website is a different medium than regular reports which are aimed for printing. Websites offer interactivity with the user, which is advantageous. Animations might be added to figures, and the user can freely browse the website while reading.

Another advantage is the use of hyperlinks. Hyperlinks might be used in-text for linking directly to further readings on a topic. Hyperlinks are also used for direct referencing to cited sources. This means the reader will not have to go via the reference list to find the source.

In websites, multimedia can be embedded. Videos are often useful illustrations and can provide a further understanding of a topic when they appear as part of the website content. Modules from other websites can easily be embedded in Wix.com. In this thesis, some flashcards made with Quizlet was embedded directly into the website.

3 Building the Website

3.1 Wix.com

Wix.com was chosen as a website builder for the master thesis. Based on experience with writing the project thesis in the old version of Google Sites, the design possibilities were found very limited. The new version of Google Sites also has a highly

limited library of themes which impose even more restrictions on design elements, like fonts and colour palette.

Wix.com is a free website builder that offers a wide range of tools and templates for easily building a website, using drag and drop functions. Wix.com offer their services to over 100 million users across the world, which makes it a commonly used website builder. The substantial Wix user community provides a profound competence base for problem-solving during website development.

Using other website builders such as Wordpress was found unnecessarily complicated for the design of the website. The goal was to easily communicate the contents of the thesis through a website. It was important to choose a website builder that was quick to learn and could easily be customised to desired design preferences.

There are a few limitations to the website builder and features that make customisation more demanding. One example is setting a default design to particular objects, such as hyperlinks. Their standard look is underlined text. Each one of them needs to be customised individually to change their looks; there is no easier way like applying a template. Another limitation is embedding YouTube films. YouTube URL's might be customised to start at a certain point in the video. When such a link is embedded in the site, Wix.com overruns this setting and plays the video from the beginning. These were minor limitations and did not extensively interfere with the design process.

3.2 Website design considerations

3.2.1 Fonts

In the website, two main fonts were chosen for the text. For textual variation and contrast, a serif font is used for the body while the headings are in sans-serif. The difference between the two is illustrated in figure 1.

Figure 1 Serif and sans serif fonts

The website is dominated by text, which should be made visually attractive and easy to read. According to a study done by Rello et al. (2016), larger fonts increase the readability of articles. A very good-looking, and text-heavy website, medium.com, has a font size of 21px. This gave the inspiration to choose the same font size for the thesis site, making it more legible.

3.2.2 Reference list

The reference list was designed as a Wix-Repeater. In this way, reusing the same design for multiple elements was very easy. The repeater was organised like a list of items which could easily be reordered. This was beneficial when ordering the list alphabetically and inserting new items. The design of an element in the list is illustrated in figure 2.

Figure 2 The design of an item in the reference list

3.2.3 Site navigation

The main navigation for the website is the top menu. It is found in the same place on every page. A drop-down menu shows the content of every chapter on the site.

The site can be freely browsed, but a reading sequence is suggested. This sequence can simply be followed by the previous and next indicators at the bottom of every page.

A search bar is included in the footer to locate a desired topic easily.

Each chapter has a colour assigned to them. This colour is used, for instance, in the underlines of headings. The first chapter, stigmergy, have a yellow colour assigned to it as seen in the example of figure 3. The colour coding can provide page orientation. The colours can help users in more easily recognising which chapter a page belongs to and which topics are related.

Figure 3 Example of how chapter colour is used in title underlining

3.2.4 Link design

There are two kinds of links used on the website, to distinguish them they are designed differently. It is crucial with visible link design in order for the users to realise the presence of the link. The perceived affordance of a link is best maximised through colour and underlining (Nielsen, 2004), and is used on the website.

Design 1, as shown in the figure 4, is used for citing and is linking to the original work. The link design underline the name of the author.

Figure 4 Design 1 

Design 2 is linking to relevant literature, mostly Wikipedia articles. The design of these links is inspired by Wikipedia, for users' recognition. The in-text links are distinctive from the rest of the text using a colour of high contrast, as seen in figure 5.

Figure 5 Design 2 

3.2.5 Responsive design

When designing in Wix.com, the design is automatically responsive to a certain extent. To achieve more responsiveness strips are used for the different sections of the website. Strips will adapt to the width of the screen and is useful in terms of a covering background-colour. The website builder has an option of redesigning some of the elements to fit a mobile screen better. This has not been done for this website as it assumed that the reader would read it on a computer screen.

3.2.6 Image referencing

When presenting a thesis as a website, the medium is different from a written report. Scientific reports have a standard way of referencing figures and tables. These are often numbered in ascending order. In the website, figures related to the text has an image description and are linked scientifically with numbers. This numbering is found less relevant for some of the images that are illustrations and not directly related to the text content. Pictures refer to their source by clicking the image itself. A new tab will open in the browser, showing the source site. Every page has a cover picture with a strip. In Wix.com, it is not possible to connect a link to strips in order to open a new tab with the source-site. In order to reference the cover pictures, a small image title has been added in their bottom left corner. The text is a clickable hyperlink, which takes the user to the source. A design example is found in figure 6.

Figure 6 Textual source to cover picture from “Other Industries”

3.2.7 Videos

Videos are embedded in several places of the site. Videos are used to supplement the written content or explain a concept further. As they are considered to be a part of the content, videos are set to autoplay. The autoplay setting in Wix.com automatically starts playing a video immediately when a page is launched. To make sure a film does not finish playing before the reader reaches it, videos are played in a loop.

4 Citation and References

4.1 Citations

The in-text citation is done in two ways. One is citing or referring to scientific articles, the other is citing other sources such as Wikipedia articles. Citing scientific articles is done similarly to APA6 style, including (Name of authors(s), year published). The name of the author is a hyperlink to the cited article, see design in figure 4 of section

3.2.4. Wikipedia articles and other websites are referenced with a hyperlink in a similar way to how Wikipedia itself uses hyperlinks, see figure 5 in section 3.2.4.

4.2 References

The reference list is inspired by APA6 but excludes some of the information found in the APA6 standards. The reference list includes links to websites with the published article, where more information is found. The reference list on the website includes the following information:
Author(s). (Year published). Article title. Link to the website of publishing.

4.3 Website References

A full list of the references used in the thesis can be found on the website under references.

The site address is https://hanneoverrein.wixsite.com/stigmergy/references.

5 Report References

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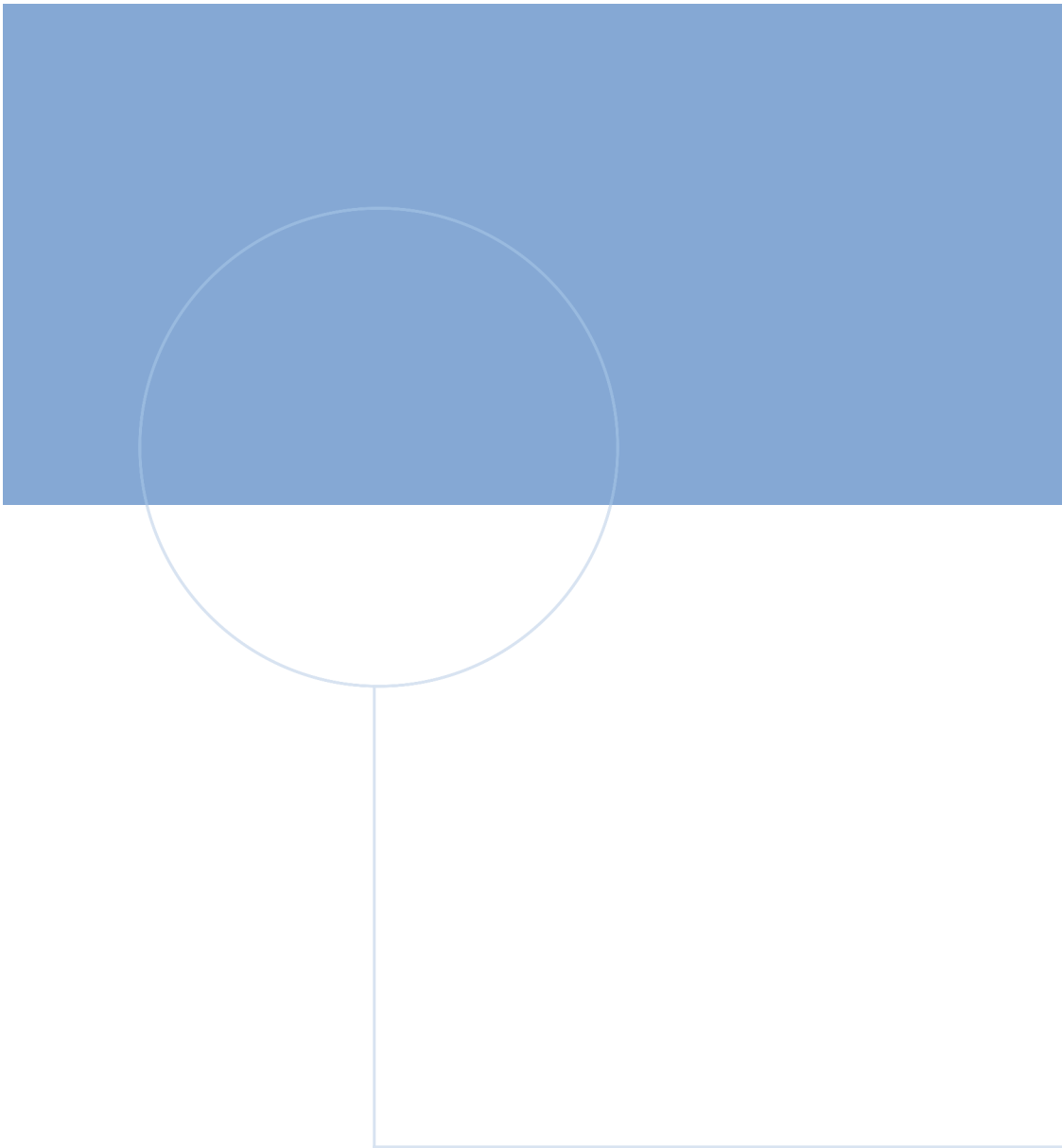

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