Fractal Analysis as Method for studying Social Hierarchy in Prehistoric Settlement Plans

with case studies from the Linear Pottery and Trypillia cultures (5.500 - 3.500 cal. BCE)

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Contents

Preface

Thanks to everyone.

fdfasdf add citation Arponen et al. (2016).

This is a *sample* book written in **Markdown**. You can use anything that Pandoc's Markdown supports, e.g., a math equation $a^2 + b^2 = c^2$.

The **bookdown** package can be installed from CRAN or Github:

```r
install.packages("bookdown")
# or the development version
# devtools::install_github("rstudio/bookdown")
```

Remember each Rmd file contains one and only one chapter, and a chapter is defined by the first-level heading #.

To compile this example to PDF, you need XeLaTeX. You are recommended to install TinyTeX (which includes XeLaTeX): https://yihui.name/tinytex/.

Part I

Frameworks

Chapter 1

Introduction

1.1 Background of the study

1.2 Research question and objectives

What are my goals for this project?

Two approaches: house-size distributions and settlement layouts

1.3 Some definitions

Just the minimum required to present the thesis in general terms.

- Hierarchy

- Inequality

- Social complexity

- Scale

1.4   Main findings here?

1.5   Research ethics

- Open science and open-source scripts

- Terminology and spelling (British English for text. For geographical place names, Slovak special characters are kept as far as possible, even though it can be a pain in the xxx to render in Rmarkdown on Windows OS, and the 2010 Ukranian National transliteration system with only ASCII characters and no soft sign)

- Abstracts in Slovak and Ukranian (and not only in Norwegian)

1.6   Structure of the thesis

Interdisciplinary subject and no single history of research chapter.

Accessibility, non-specialised readers: technical details are, as far as possible, limited to the dedicated chapters (**??**).

Describe the parts (including this one).

Text

Here I skipped a line.
Here I added a backslash.

fdsasdfasdf You can label chapter and section titles using `{#label}` after them, e.g., we can reference Chapter **??**. If you do not manually label them, there will be automatic labels anyway, e.g., Chapter **??**.

Figures and tables with captions will be placed in `figure` and `table` environments, respectively.

```
par(mar = c(4, 4, .1, .1))

plot(pressure, type = 'b', pch = 19)
```
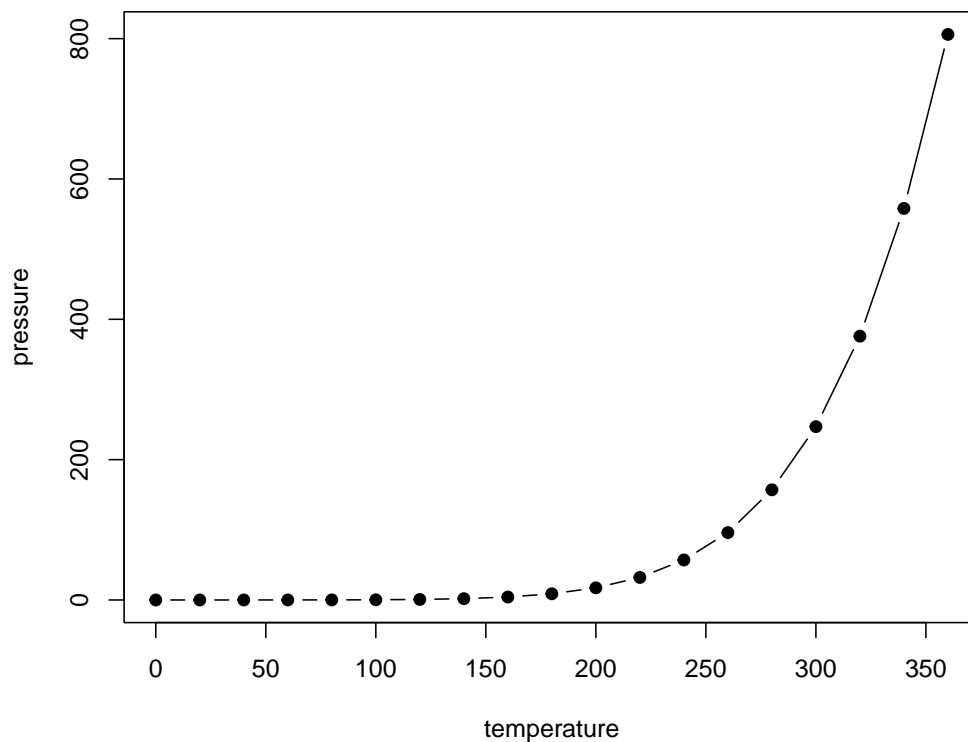

Figure 1.1: Here is a nice figure!

Reference a figure by its code chunk label with the `fig:` prefix, e.g., see Figure 1.1. Similarly, you can reference tables generated from `knitr::kable()`, e.g., see Table 1.1.

```
knitr::kable(
  head(iris, 20), caption = 'Here is a nice table!',
  booktabs = TRUE
)
```

You can write citations, too. For example, we are using the **bookdown** package (Xie 2022) in this sample book, which was built on top of R Markdown and **knitr** (Xie 2015).

Table 1.1: Here is a nice table!

Sepal.Length	Sepal.Width	Petal.Length	Petal.Width	Species
5.1	3.5	1.4	0.2	setosa
4.9	3.0	1.4	0.2	setosa
4.7	3.2	1.3	0.2	setosa
4.6	3.1	1.5	0.2	setosa
5.0	3.6	1.4	0.2	setosa
5.4	3.9	1.7	0.4	setosa
4.6	3.4	1.4	0.3	setosa
5.0	3.4	1.5	0.2	setosa
4.4	2.9	1.4	0.2	setosa
4.9	3.1	1.5	0.1	setosa
5.4	3.7	1.5	0.2	setosa
4.8	3.4	1.6	0.2	setosa
4.8	3.0	1.4	0.1	setosa
4.3	3.0	1.1	0.1	setosa
5.8	4.0	1.2	0.2	setosa
5.7	4.4	1.5	0.4	setosa
5.4	3.9	1.3	0.4	setosa
5.1	3.5	1.4	0.3	setosa
5.7	3.8	1.7	0.3	setosa
5.1	3.8	1.5	0.3	setosa

Chapter 2

Theoretical framework: Complexity and Fractals

2.1   Very short introduction to Complexity Theory / Dynamical Systems Theory

Lit. use Daems (2021) and Bentley and Maschner (2007).

For Dynamical Systems, use Awrejcewicz and Grzelczyk (2020) and Devaney (2020), but don't go into detail.

Describe complexity, dynamical systems, chaos, feedback loops, criticality, emergence.

Mention the most common applications in Archaeology: ABMs, **and what**? check in literature.

2.2   Very short introduction to Fractals and Fractal Analysis

Lit. use Mandelbrot (1982), Falconer and Falconer (2013) (general), also C. Brown and Liebovitch (2010), C. T. Brown, Witschey, and Liebovitch (2005) and Diachenko (2018) (for Archaeology)

Two sentences on history of fractals? Mandelbrot. Maybe cut?

Fractals as irregular patterns/structures

Fractals as hierarchy

Self-similarity and scale invariance

Processes/mechanisms that produce fractals:

- Cascading bifurcations and confluences (splitting or merging - tree structure/arborescence/branching, and relation to size. Terminology borrowed from biology and fluid dynamics (including turbulence/turbulent flow)

The role of randomness - tidy and messy fractals (romanesco broccolis are not more fractal than regular broccolis, only more regular.

The relationship with criticality and chaos: deterministic *and* unpredictable

Fractals embedded in

- Space (hence "fractal geometry"): geomorphology, plants, ocean and wind currents, galaxies, also human constructed features (see Chapter xx for details)

- Time series: earthquakes, finance (not applied in this study, though should be done later)

- Networks/abstract: hierarchical organisations, income distributions, word counts, 1/f or pink noise, www. etc. (see Chapter xxx for details)

- Pure mathematics: Julia and Mandelbrot sets, strange attractors (don't go into details!)

No, not everything is fractal: e.g. Central Limit Theorem

Fractal analysis for studying irregular phenomena (methods described in more detail Chapters xxx), and thus as a tool for quantitative empirical research.

2.3 Very short introduction to micro-macro approaches in social theory

- Lévi-Strauss and Structuralism

- Giddens and Structuration Theory

- Delanda and Assemblage Theory

- Latour and Actor-Network Theory

What these approaches all have in common, is that they are entirely qualitative (**check**).

- That's not a problem in itself.

- Quant approach is both possible for the stated purpose, and desirable for reasons of comparative analysis.

- Data deluge (refer to chap. on geomagn data). The goal here is to establish a quantitative framework for studying social complexity and hierarchy in archaeological/prehistoric settings. Further articulating fractal analysis with existing social theoretical approaches is not the primary goal here, as it could constitute a separate research project. In the present thesis, bla bla.

END chapter.

Math can be added in body using usual syntax like this

p is unknown but expected to be around 1/3. Standard error will be approximated

$$SE = \sqrt{(\frac{p(1-p)}{n})} \approx \sqrt{\frac{1/3(1-1/3)}{300}} = 0.027$$

You can also use math in footnotes like this[1].

We will approximate standard error to 0.027[2]

---

[1] where we mention $p = \frac{a}{b}$

[2] p is unknown but expected to be around 1/3. Standard error will be approximated

$$SE = \sqrt{(\frac{p(1-p)}{n})} \approx \sqrt{\frac{1/3(1-1/3)}{300}} = 0.027$$

Chapter 3

Material and data: social complexity in the European Neolithic

3.1 Studying social complexity in Archaeology and Prehistory.

- Grave goods

- Burial monuments

- The denominator problem

- The use of ethnography

- Other approaches (osteological, isotopes **refs**)

- This project: house-size distributions and settlement layouts (details in subsequent chapters), just very short argumentation

3.2 The Linear Pottery culture complex

- General intro to the culture

- The Žitava valley and research project

- Organisation of Linear Pottery society: egalitarian or hierarchic?

3.3 The Cucutení-Trypillia culture complex

- General intro to the culture

- The B2/C1 and the mega-sites of the Southern Bugh – Dnipro interfluve

3.4 Reading site plans from geomagnetic imagery

- Caveats: fill in here.

3.5 Synthetic data

- And why I'm not (this time) relying on ethnographic data.

- Don't go into technicalities here, just the reasoning.

Part II

Size distributions

Chapter 4

House sizes and social meaning

4.1 What is social hierarchy?

- Political assumptions – all hierarchical social structures are not despotic top-down rule. Democracies can also be very hierarchical. Matter of scale rather than political system Graeber and Wengrow (2021). But, tendencies?

- Nested and non-nested social hierarchies, hierarchical hunter-gatherers? Hamilton et al. (2007), Whitridge (2016)

- Biologically defined thresholds to group size? Dunbar's number and controversies, Dunbar (2022), West et al. (2023) (add published papers). Scalar stress G. A. Johnson (1982), Alberti (2014), Zhou et al. (2005)

4.2 Social typologies and their critique

- Tools for classifying societies, or evolutionary model? Discussion of A. Johnson and Earle (1987), Testart (2005), Service (1971)

- Critique in Yoffee (1993), Yoffee (2005), Graeber and Wengrow (2021) ++

4.3   Possible reasons for house-size difference

Often underlying assumptions: household wealth or size? Or both?

- Kinship and households: who lives in a house? Sahlins (2013), Ensor (2013), Ensor, Irish, and Keegan (2017)

- Do clan leaders have bigger houses?

Discuss some archaeo references

Functional difference:

- Ethnography of initiation houses, communal/assembly houses, ritual houses, including Barley (2011), Godelier (1986), Wilk (1983), Fraser (1968)

- Caveats: building materials and constraints

4.4   Interpreting distribution types and their underlying mechanisms

- Power-law distributions, hierarchy and scale invariance.

- Normal distributions and the Central Limit Theorem.

- Exponential distributions and growth rates.

- Combinations: Log-normal, stretched exponential, parabolic fractal

4.5   Usage in Archaeology

Lit. use Strawinska-Zanko et al. (2018), Crabtree et al. (2017), Maschner and Bentley (2003), Grove (2011) ++

Settlement scaling and Zipf law (here, or in next chapter?)

END chapter

Chapter 5

Methods: Distribution fitting

5.1 Heavy-tailed distributions, testing for power laws

- Technical characteristics of power laws, Newman (2005), do I need more?

- Old style distribution fitting (which is used in C. Brown and Liebovitch (2010) and C. T. Brown, Witschey, and Liebovitch (2005) and check.

- New style presented in Clauset, Shalizi, and Newman (2009), implemented in R with the poweRlaw package Gillespie (2015), and used in Strawinska-Zanko et al. (2018) and Crabtree et al. (2017). More recent?

5.2 Methodological procedure

- Synthetic data genaration

- Parameter settings: dist. types, xmin, testing the pl hypothesis etc. Minimal house-count cutoff (min. sample size). Isolating top house.

- Phasing of Vráble

-

5.3   Notes on terminology: Power law, Pareto and Zipf

- A law (distribution) is not a law (of nature), see Grove (2011) for review of the long-lasting confusion in Archaeology (e.g. Hodder (1979)), also rank-size " rule"

- Zipf law and Settlement Scaling theory, Bettencourt (2021), Gomez-Lievano, Youn, and Bettencourt (2012), Lobo et al. (2020) (possibly move this to preceding chapter). Why I'm not doing settlement scaling in this study.

END chapter

Chapter 6

Results: Distribution fitting

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END Chapter

Part III

Settlement Plans

Chapter 7

Village planning in Prehistory

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END Chapter

Chapter 8

Methods: Fractal image analysis

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END Chapter

Chapter 9

Results: Image analysis

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END Chapter

Part IV

Synthesis

Chapter 10

Discussion: Social complexity in Linear Pottery and Trypillia settlements

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END Chapter

Chapter 11

Discussion: Fractal Analysis and Archaeological data

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END Chapter

Chapter 12

Conclusion and Outlook

12.1 Things I would like to have done, but that didn't fit into this study

- Ethnoarchaeology: Measure house sizes and settlement layouts in contemporary settings, and relate to social organisation (largely overlooked by ethnographers)
- Test distributions and settlement layout analysis on other settings: Lake dwellings, later/historic periods, other materials (e.g. megaliths)… Add more complex distribution models, add observation windows on images. Try on remote sensing imagery.
- Settlement Scaling on Neolithic settings
- Time series: Hurst exponent and scale invariance in temporal development of e.g. regional settlement or population
- Integrate – bridge the gap – between opposite theoretical (nat. and soc./hum.) approaches to the same phenomena
- Chaos and strange attractors in Archaeology
- More?

12.2   Concluding remarks

END Thesis

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Appendix A

This is my first appendix

Jada jada jada

Appendix B

This is my second one

Bla bla bla