Informatics to Students of Cognitive Science

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1 Introduction

1.1 The purpose and structure of these notes

The primary purpose of these interactive notes is to cover the material corresponding to the one-semester course Informatics to Students of Cognitive Science at the Budapest University of Technology and Economics.

Interactivity is made possible by the computer system Mathematica, on which the Informatics Course is based-therefore, the current notes try to serve as a gentle introduction to this software as well.

We will be led into different aspects of Mathematica through examples, simultaneously illustrating various concepts in informatics, although, due to time limitations, only a small

fraction of the capabilities of the software can be covered (we are going to encounter only a few percent of the current Mathematica commands). Interactivity means that you can (and should!) easily reproduce or modify the examples given in this document-also called Mathematica notebook. In fact, in our opinion, the best way to learn these concepts is to freely change the given inputs (adjust the parameters, play with the sliders, and so on) and explore the consequences.

Let us also point out that the name Mathematica is a bit narrowly defined, because nowadays, as we will see, it is much more than a tool for doing traditional mathematics. Together with Mathematica we are going to learn some parts of its underlying language, the Wolfram Language. Mathematica has been one of the earliest manifestations of the Wolfram Language, but in the near future we will meet this language more and more often-e.g., in mobile applications, or in the computational knowledge engine Wolfram Alpha introduced in 2009. Wolfram Alpha is already used, for example, by hundreds of thousands of students to help solving their homeworks, but it can even easily analyze your connections within your favorite social networking site.

A list of the main themes of these notes in each chapter is given below (Mathematica commands or code pieces in the text will most often be denoted by this style).

In Chapter 2, we will focus on how to create simple but non-trivial 2D or 3D, static or interactive visualizations by using the Manipulate and Animate commands. Our visualizations will include classical geometric shapes (the graphics primitives), but we will also explore the bones of a foot, design smileys, flags, rings or a solar system, deform a doughnut, fade images, create a clock, or play some music. Chapter 3 deals with string manipulation and shows some simple applications in linguistics. The central theme in Chapter 4 is classical algebra but from a more interactive viewpoint. In Chapter 5, we are going to interactively explore some properties of sequences, series, functions or iterations. In Chapter 6 we present two, more involved applications: one on charting data and one on music recognition. Finally, in the last chapter, serving as an Appendix, a brief but broader overview of Mathematica is presented: after some historical remarks, some current and typical application areas are collected, together with the most important elements of Mathematica syntax and language, and several useful tips on the efficient use of the software.

For your reference, at the end of each chapter, a Summary section is given where we have collected the most important Mathematica commands newly covered in that chapter.

Sections within each chapter typically begin with one more complex initial example or its variants, motivated by real-life applications. These working code examples will be denoted by this background color:

```
Manipulate[ImageTake[ ..., {startingslice,
Min[startingslice+layerthickness,51]},{1,34},{1,35}],
{startingslice,1,51,1}, {layerthickness,0,50,1]
```

Your instructor will show you how to evaluate these pieces of code. After discussing the significance of the example, we will deconstruct these compound commands into some simpler building blocks and study them individually in more detail as well as in different contexts to understand their behavior and what concept they illustrate. This phase will generally take place after an Explanation: details and variants sign.

Exercise. Many additional exercises (without solutions) will appear within each chapter. These exercises are marked with this background color. Your instructor will let you know whether you have to study and solve them on your own or in a group.

As a general rule, the approach taken in these notes is the following: instead of a systematic treatment or introduction to the software, we are going to analyze several examples in each section. In other words, we are going to follow an application-oriented "right in the middle approach" rather than a more exhaustive "from bottom to top approach".

Throughout this document it is assumed that you are already familiar with the basics of Mathematica syntax. Hence, during your Informatics Course, and especially in the first weeks, your instructor may direct you to the Appendix at the end of this document from time to time to study or discuss some relevant paragraphs.

A note on the software and hardware. This notebook has been created in Mathematica version 9, so in order to take full advantage of all the interactive features discussed in this document, it is recommended that you have the latest available Mathematica version. Moreover, some examples-especially the ones dealing with 3D imaging-require a fast enough computer to run smoothly. Other examples may require Internet connectivity. Finally, as we sometimes also generate music, a machine with audio capabilities is recommended.

1.2 Additional resources

There are thousands of pages on the web concerning Mathematica. Let us list only four of them as further references. Active hyperlinks throughout this document are marked as usual.

A complete Mathematica documentation in English is available on-line at *http://reference.wolfram.com/mathematica/guide/Mathematica.html*.

A 396-page overview on the software (published in 1996 in Hungarian) can be freely downloaded from *http://www.math.bme.hu/~jtoth/Mma/M_M_2008.pdf*.

A rich source of various Mathematica-related documents is found at http://www.math.bme.hu/jtoth/Mma/mma.html.

Finally, many interesting teaching materials written in Mathematica are collected at http://www.model.u-szeged.hu.

1.2.1 Acknowledgement and sources

The authors of these notes are indebted to their colleagues János Tóth and Gergely Gyebrószki for sharing their expertise and experiences, and providing us with several Mathematica code examples that have been used in the current document.

Other code pieces, graphs, and 2D or 3D images shown in this document (as tasks, exercises or illustrations) were taken from the public domain; typically, from the Mathematica documentation itself or from the *http://demonstrations.wolfram.com* site-otherwise, credit is given to the original source. We then freely modified or transformed some of these objects to illustrate our goals better.

The topmost image of this notebook is part of a sliced, false-color image of nanoflowers made from zinc-doped tin oxide (downloaded from *http://www.wired.com/wiredscience* and sliced with Mathematica).

The complete interactive Mathematica notebook and the corresponding PDF can be downloaded from

https://www.dropbox.com/s/uaaet09f9o1s5kv/Informatics with Mathematica.pdf.