Professional Basic English
Lecture 13

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Typical sections in a scientific article/thesis

- Abstract
- Introduction
- Background / Related Work / Literature Review
- Description of the work / study (Body):
  - Survey / tutorial paper: Thematic division in sections
  - Experimental paper: Methodology, Results
  - Theoretical paper: Phenomenon, Theoretical contributions
- Discussion, Conclusions

Writing the body

- Format of the body of the paper depends on the type of the paper (survey, experimental study, theoretical study)
  - Survey and tutorial papers do not need literature review section, because the whole paper is literature review
- Focus on the organization and the flow
  - Logical flow from introducing different aspects of the problems, motivating your chosen approaches, moving up and down from generalizations to the different levels of details: building a story of your work

Writing a survey paper

- Requires much wider perspective than typical research papers
  - Survey is typically an important part of a thesis
- Typically divided in sections based on different aspects of the same problem
  - Different implementations of a method or algorithm: different purposes and platforms (e.g. software vs. hardware, mobile vs. workstation, industrial vs. consumer applications)
  - Different technical aspects (e.g. video streaming: networking and signal processing aspects)
  - Evaluation and comparison of different approaches (features, measures, applicability for different use cases or scenarios)

Survey paper: focus in the topic

- Outlines the most important issues within a topic that have been studied and what issues are the most relevant
  - Could also be an overview article with the focus on some new method, standard etc.
- Suggests and motivates different research directions
  - Evaluation of ongoing research efforts and their relevance
  - Prediction of future developments: what will be relevant?
- Possibly includes some kind of “meta-study”
  - “Study of the studies”: some kind of methodology applied to compare different studies and evaluate their relevance

Writing an experimental paper

- Experimental research paper describes a scientific experiment
  - For example physical experiment or user (usability) study
  - Also implementing some kind of method or product in practice (algorithm, software, hardware) could be considered as an experiment
  - Some kind of parameter to be measured (e.g. measurements of some physical attributes, user feedback)
- Two main parts: methodology and the results
  - Methodology part describes the test arrangements, environment, used software and hardware at the appropriate level of details (ideally, others should be able to repeat the experiment)
  - Results part describes the outcome of the experiment: numerical results, discussion and reflections, practical significance

Experimental paper: focus in the results

- First, a hypothesis is formulated (based on the prior knowledge and possibly similar experiments)
  - What kind of results would be expected?
  - Could be (in rare cases) replication of an older study: can the earlier results be reproduced?
- Second, the results presented, analyzed and discussed
  - Is the result similar to the hypothesis? If not, what could be the reason?
  - What kind of conclusions can be derived from the results? Is there need for more studies to continue the work?
  - What kind of practical significance the results will imply?

Writing a theory paper

- A theory paper advances theoretical knowledge of some topic
  - Seeks for an explanation for an observation or phenomenon
  - Could be for example derivation of a mathematical model or algorithm, possibly validated via simulations (in this case, the borderline between experimental paper and a theory paper is not so clear)
- The new theory may have practical applications (or not)
  - Is it possible to predict some phenomenon more accurately using the newly developed theory?
  - Sometimes theory is developed with no obvious applications (but there may be applications in the future)

Theory paper: focus in the phenomenon

- First, the studied phenomenon is defined and explained
  - The theory related to the phenomenon is summarized
  - If there is experimental data available from other sources, it is described and possibly used in the study
- Second, the theoretical contributions are linked to the phenomenon
  - Will the theoretical contribution reveal some new knowledge about the old data or old theory?
  - Are there some practical applications of the new theory?

Classroom task 1

- Have a look at the three research papers (paper 1, paper 2, and paper 3 – it is enough to read the abstracts and skim through the content)
  - Which sections form the body of the paper?
  - Is the paper survey paper, experimental paper, or theory paper?
  - What is the main contribution of each paper?

Equations, tables, illustrations

- Scientific text, especially in natural sciences and engineering, typically require different forms of information in addition to the plain text
  - Mathematical equations
    - In computer science, sometimes also pseudocode
  - Tables with numerical or other information
    - Typically accompanied with a caption and potentially additional information as a footnote
  - Graphical presentations: graphs, flowcharts, block diagrams, figures
    - Illustrations include a caption, sometimes divided into subfigures
    - Figures (including different types of illustrations) numbered

Using equations

- Equations are typically numbered so that they can be referred in text
- Variables need to be explained when used for the first time
- You should avoid using the same variable name in different equations for different purpose

Example: We can compute the average brightness *B* of the image by using Equation (3):

$$B = \frac{1}{w \cdot h} \sum_{x=0}^{w-1} \sum_{y=0}^{h-1} b(x, y)\,, \qquad (3)$$

where *w* is the width of the image, *h* is the height of the image, and *b*(*x*,*y*) is the brightness of the pixel in position {*x*,*y*}.

Using pseudocode

- Typical format similar to programming languages
  - Simplified, not strictly following any real programming language
- Allows to explain algorithms with *for*-loops, *if-then-else* –conditions and other basic features of computer programs

Example: algorithm to find the maximum value of vector $X=\{x_0, x_1, \ldots, x_{N-1}\}$

```
maxval := x0
for i := 1 to N-1
    if xi > maxval
        maxval := xi
    endif
endfor
return maxval
```

Using tables

- Useful for listing e.g. numerical information
  - Challenge to find the proper format: depends on the page layout
  - Very large tables can be boring to read, better to avoid
  - Table captions and labels should be short yet informative; more information can be given in the text describing the table

Table I. Performance of different methods for image denoising compared in terms of PSNR*.

	Image: 1 Noise: σ_1	**Image: 2 Noise: σ_1**	**Image: 3 Noise: σ_1**	**Image: 4 Noise: σ_1**	**Image: 1 Noise: σ_2**	**Image: 2 Noise: σ_2**	**Image: 3 Noise: σ_2**	**Image: 4 Noise: σ_2**
Noisy	27.52	26.11	32.41	21.86	24.32	22.18	30.97	19.88
Method A	28.41	27.22	33.51	24.15	25.01	23.09	31.87	23.11
Method B	28.89	28.15	33.78	23.98	25.21	24.11	33.22	24.05
Method C	29.11	28.27	34.01	24.32	26.08	24.82	33.18	25.12

*) PSNR is a measure of image similarity. Larger value means typically higher quality of the image.

Using graphs

- Usually more illustrative than tables, when different attributes can be presented as a function of another attribute
  - Subtypes: functions, scatterplots, bar charts etc.
- Typical expressions:
  - … *In Figure 1, we have plotted the results of Z as a function of Y …*
  - … *Relationship between X and Y is depicted in Figure 2 ...*
  - … *Figure 3 shows the dependency of Y from X …*
  - … *The results with different parameters are plotted in Figure 4 …*
  - … *The bar chart in Figure 5 shows the education level in different X …*

Graph examples with captions

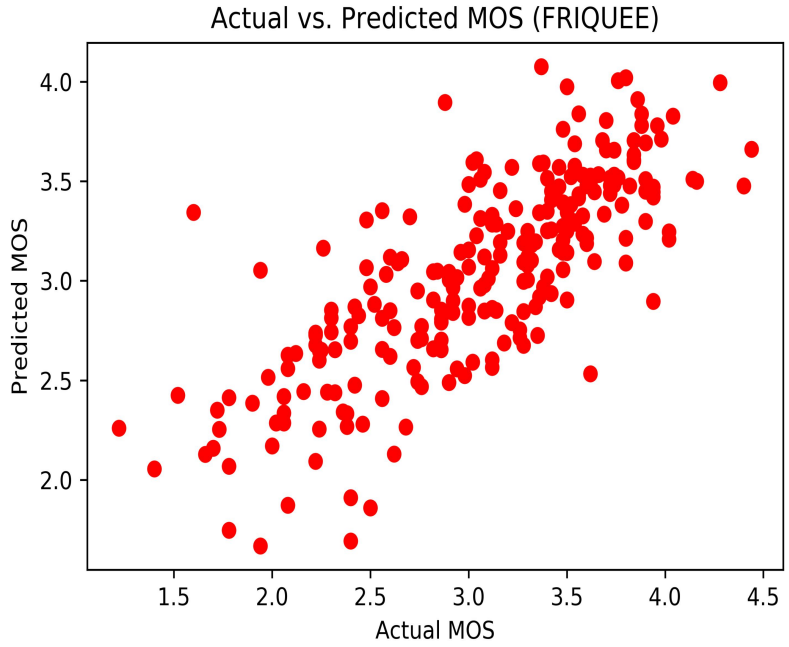


Figure 1. Scatterplot of the predicted MOS values.

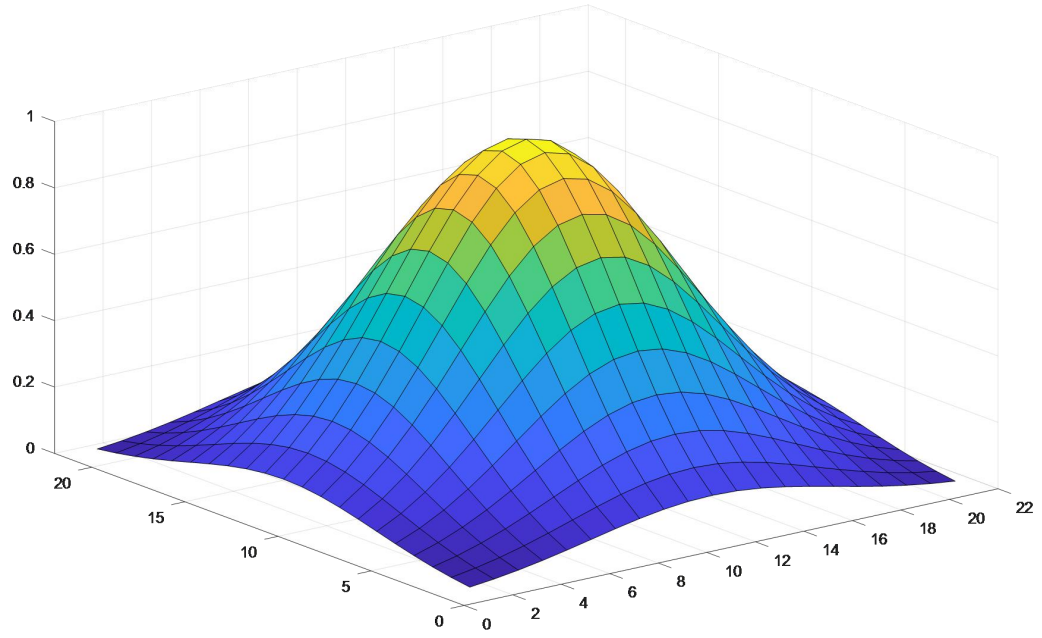


Figure 2. Two-dimensional Gaussian function illustrated.

Graph examples with captions (2)

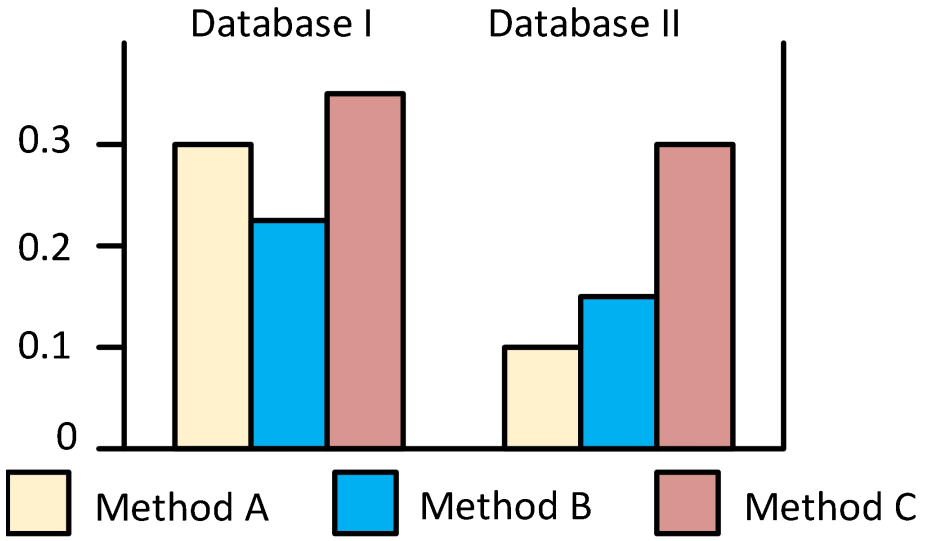


Figure 1. Average prediction error with methods A, B, and C, using databases I and II.

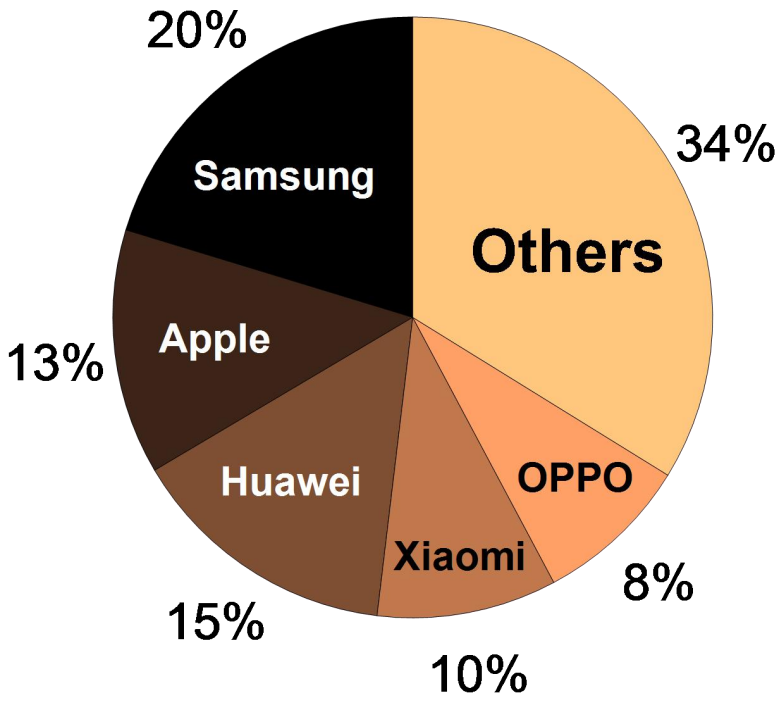


Figure 2. Market share of different smartphone brands.

Explaining the graphs

- In the text, it is typically necessary to explain and discuss the findings illustrated in the graphs
  - *… As Figure 1 shows, model X can predict values of Y relatively accurately …*
  - *… The results in Figure 2 demonstrate that X and Y are highly correlated …*
  - *… The peaks in the autocorrelation function in Figure 3 show that phenomenon X occurs periodically …*
  - *… As depicted in Figure 4, there is generally a good agreement between attributes X and Y …*
  - *… The plot in Figure 5 shows a clear tendency of …*
  - *… The chart in Figure 6 illustrates the distribution of X under condition Y …*

Other illustrations

- Different technical ideas and concepts often easiest to explain with appropriate illustrations
  - Best to draw illustration first, then explain the illustration in the text
  - Different illustrations for different purposes
    - Flowcharts often useful for explaining algorithms or decision logic
    - Block diagrams often useful for explaining complex systems containing subsystems
    - Technical drawings useful for explaining hardware and mechanics
    - Recommended to find examples in related papers
  - Consider carefully which illustration type to choose: inappropriate illustrations may be hard of impossible to explain verbally

Example blockchart

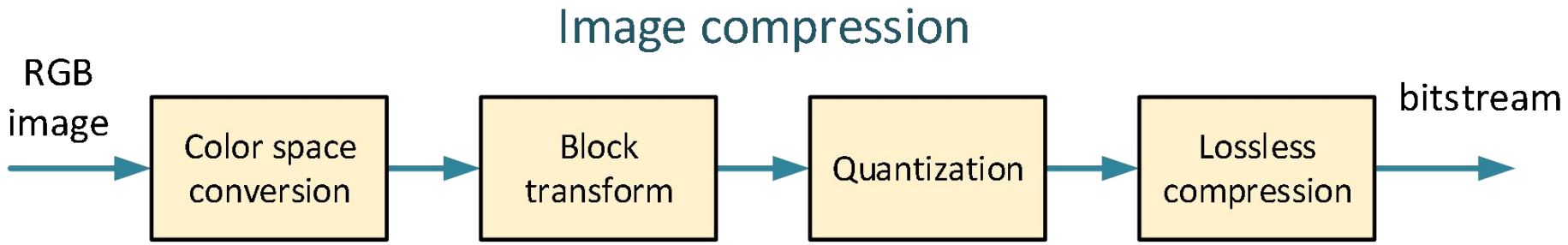


Figure 1. An image compression system illustrated.

Example description:

Figure 1 shows the main components of a generic image compression system. First, RGB images are converted to another color space, such as YUV. Then, block transform, based on Discrete Cosine Transform (DCT), is applied. In the next phase, DCT coefficients are quantized, and finally, the quantized DCT coefficients are coded with lossless compression to compose the output bitstream. At the decoder, the same process is repeated inversely.

Example flowchart

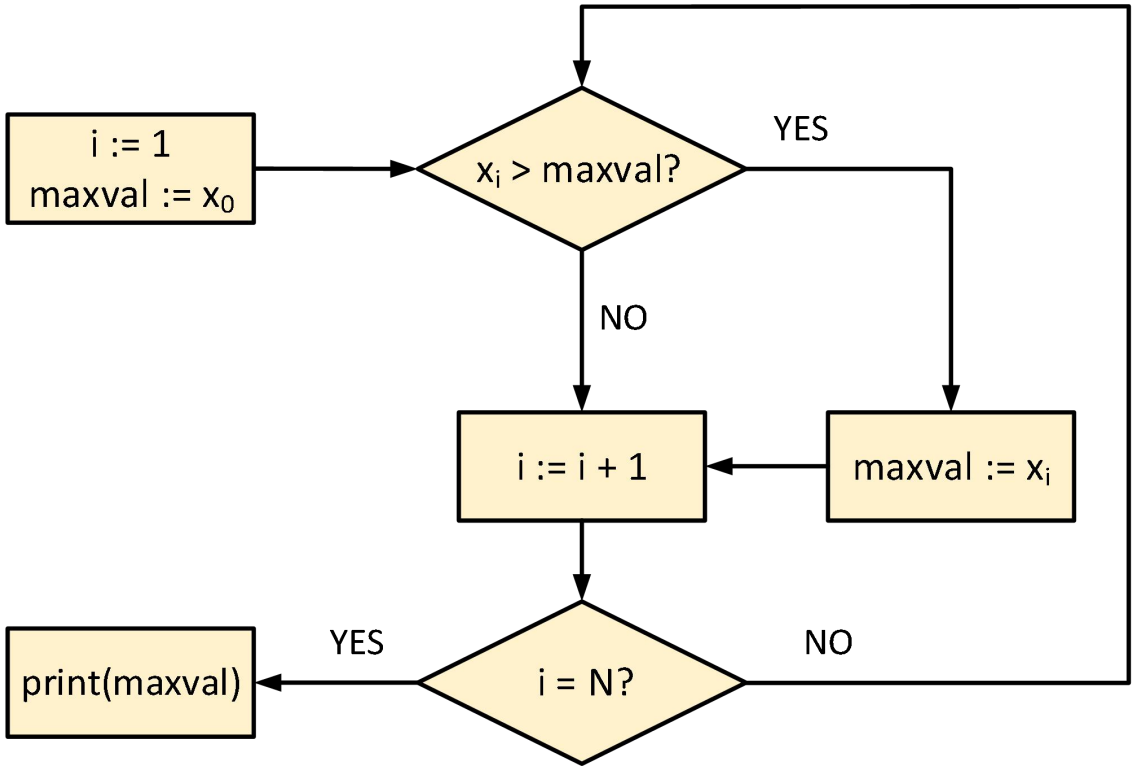


Figure 1. Flowchart of the algorithm to find the maximum value of vector X.

Example description:

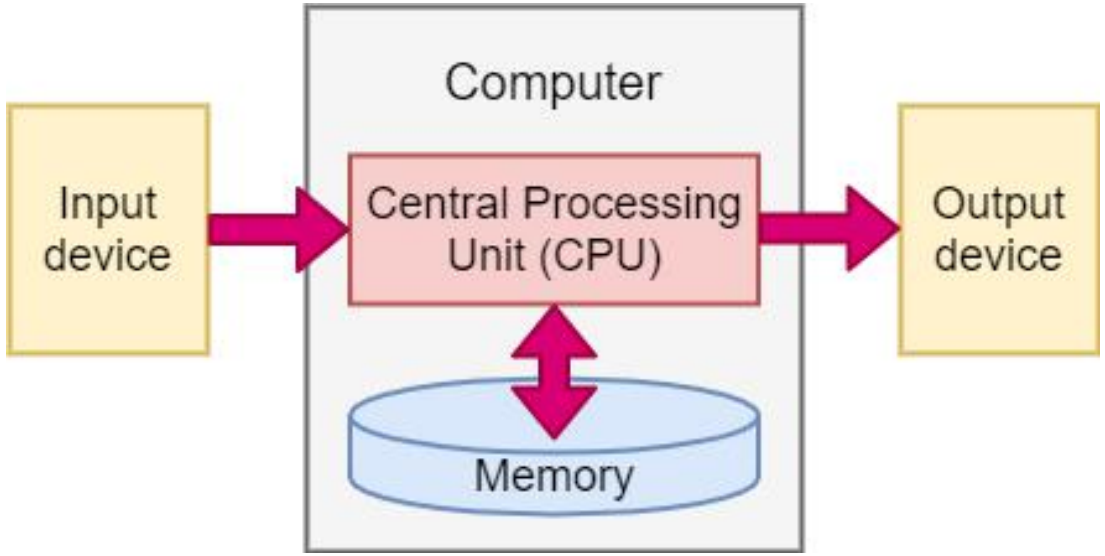
Figure 1 shows the flowchart of the algorithm to find the maximum value of vector $X=\{x_0, x_1, \ldots, x_{N-1}\}$. The algorithm goes through all the elements in the vector to find the maximum, and in the end it prints out the result.

Classroom task 2

- Look at the results in Tables I and II. What kind of graphical representation you would choose to illustrate the findings? Justify.

Homework 4

- Explain briefly (about 150 words) the basic components of a computer based on von Neumann architecture, using the figure below. Deadline: 16. December.



Writing the body: summary

- Rough division to survey papers, experimental papers and theory papers
  - Many papers have characteristics of more than one type
- Typical structure of science paper body has sections for (at least) method and results
- Focus on illustrations (charts, diagrams, tables etc.) and explaining them