By far the most common structure of a scientific paper is IMRAD. The acronym comes from the words introduction, materials and methods, results, and discussion. A good paper follows the hierarchical top-down approach and unlike a textbook it is written for experts in the field. The selection of journals and conferences for the manuscript will be explained. When writing the paper, the audience must be taken into account to guarantee readability. In addition, originality, significance, and correctness are essential requirements for a scientific paper, as also explained in later sessions.

• Introduction
• IMRAD structure of a paper
• Organization of a paper
• Selection of forum
• Conclusions
Introduction (1)

- Problem
- Initial data collection (literature review)
- Tentative solution (hypothesis)
- Analysis/simulations/experiments
- System model (prototype)
- Theory/paper (new knowledge)

Introduction (2)

- High reliability, low newness
  - Encyclopedias
  - Monographs
  - Textbooks
  - Review papers
  - Tutorial papers
- Own papers
  - Original journal papers
- Literature reviews
  - Other original papers
  - Conferences
  - Symposia
  - Workshops
- Reports

Low reliability, high newness
Introduction (3)

• Motivation for writing scientific papers [Sternberg81]
  • distribution of knowledge
  • improves the quality of research (“Olympic Games”)
  • measure of scientific merit of the researcher and of the
    employer (peer review process)
• general aim is the reproducibility of experiments (no
  implicit assumptions allowed) [Day98]
• IEEE paper is used as an example (check publisher’s
  instructions for details)
• Length of the manuscript typically 7 pages for letters, 20
  pages for full journal papers, and 5 pages for conference
  papers
• Think of the readers, do not write for yourself!

Most important IEEE writing instructions

• IEEE Author Digital Tool Box,
  www.ieee.org/web/publications/authors/transjnl/index.html
• Author’s template for IEEE papers,
  www.ieee.org/portal/cms_docs_iportal/author/templates/journmag/transition/
  TRANS-JOUR.doc
• Manuscript Templates for Conference Proceedings,
• V. O. K. Li, “Hints on writing technical papers and making presentations,” IEEE
• S. D. Senturia, “How to avoid the reviewer’s axe: One editor’s view,” IEEE Journal

Preparation of Papers for IEEE TRANSACTIONS
and JOURNALS (May 2007)

16.9.2008 Aarne Mämmelä

VTT TECHNICAL RESEARCH CENTRE OF FINLAND
IMRAD Structure of a Paper [Day98]

I. Introduction
- What question or problem was studied?
- Write the whole literature review here, do not continue it elsewhere.

II. Methods (model)
- How was the problem studied?
- Describe the whole system model here (parameters presented with symbols), do not continue the system model description elsewhere.

III. Results
- What were the findings?
- These must be your own results. Plagiarism (also self-plagiarism) strictly forbidden. Give numerical values of all parameters (guarantee repeatability).

IV. Discussion
- What do these findings mean?

Structure of an IEEE paper [Spectrum65]

Abstract
1. What the author has done.
2. How it was done (if it is important).
3. Principal results (numerically, when possible).
4. Significance of the results.

Glossary (only in reviews)

I. Introduction
1. Nature of the problem.
2. Background of previous work.
3. Purpose and significance of the paper.
4. Method by which the problem is approached.
5. Organization of the paper.

II. Materials and methods (Model)

III. Results

IV. Conclusions
1. What is shown by this work and its significance.
2. Limitations and advantages.
3. Applications of the results.
4. Recommendations for further work.

Acknowledgment

References

Photograph and biography
Structure of an IEEE paper (2)

[Spectrum65], [Day98]

READERSHIP (PAST)

Introduction (motivation, orientation)

Scope

Methods and Results

Conclusions

FUTURE

Example original paper

Maximum-Likelihood Sequence Estimation of Digital Sequences in the Presence of Intersymbol Interference


Title [Spectrum65]

- Not too general
- Brief, clear and descriptive
- Less than ten words
- Emphasize novelty

List of Authors [Day98]

- at most four or five names recommended
  - include those who had scientific contribution (i.e., those who solved engineering problems)
  - the order of the names reflect the significance of the contribution (first name is by far the most important)
- those who acquired funding are mentioned in the acknowledgment section
- give the name and address of your employer
- if your employer was changed during the preparation of the paper, write “NN was with X. He is now with Y.”
Abstract (1)

1. What the author has done.
2. How it was done (if it is important).
3. Principal results (numerically, when possible).
4. Significance of the results.

Abstract—A maximum-likelihood sequence estimator for a digital pulse-amplitude-modulated sequence in the presence of finite intersymbol interference and white Gaussian noise is developed. The structure comprises a sampled linear filter, called a whitened matched filter, and a recursive nonlinear processor, called the Viterbi algorithm. The outputs of the whitened matched filter, sampled once for each input symbol, are shown to form a set of sufficient statistics for estimation of the input sequence, a fact that makes obvious some earlier results on optimum linear processors. The Viterbi algorithm is easier to implement than earlier optimum nonlinear processors and its performance can be straightforwardly and accurately estimated. It is shown that performance (by whatever criterion) is effectively as good as could be attained by any receiver structure and in many cases is as good as if intersymbol interference were absent. Finally, a simplified but effectively optimum algorithm suitable for the most popular partial-response schemes is described.

Abstract (2) [Spectrum65], [Spectrum66]

• abstract is a short one-paragraph summary of the paper
• length usually limited to 50 words in letters and 75-200 words in full journal papers plus a few key words
  • conference papers max. 150 words
• the first sentence (topic sentence) establishes the context and scope of the paper
• identify important ideas: make it informative, not descriptive, i.e., not merely a table of contents, emphasize novelty
Abstract (2) [Spectrum65], [Spectrum66]

• author's own new contribution, conclusions and recommendations must be emphasized
• must be understandable independently: no references to the paper, no citations, no obscure abbreviations
• include only information mentioned in other parts of the paper
• below the abstract, give about four key words or phrases in alphabetical order

Introduction (1)

INTERSYMBOL interference arises in pulse-modulation systems whenever the effects of one transmitted pulse are not allowed to die away completely before the transmission of the next. It is the primary impediment to reliable high-rate digital transmission over high signal-to-noise ratio narrow-bandwidth channels such as voice-grade telephone circuits. Intersymbol interference is also introduced deliberately for the purpose of spectral shaping in certain modulation schemes for narrow-band channels, called duobinary, partial-response, and the like [1]-[3].

The simplest model of a digital communication system subject to intersymbol interference occurs in pulse amplitude modulation (PAM), illustrated in Fig. 1. A sequence of real numbers $x_i$, drawn from a discrete alphabet passing through a linear channel whose impulse response $h(t)$ is longer than the symbol separation $T$, and the filtered signal

$$s(t) = \sum_{x} x_i h(t - kT)$$  (I)
Introduction (2)

LITERATURE REVIEW IS HERE!
AFTER THIS WRITE THE NOVELTY CLAIM!

While lip service has long been paid to the idea that symbol decisions ought to be based on the entire received sequence, the fact that straightforward likelihood calculations grow exponentially with message length [4] has justified a retreat to simple symbol-by-symbol decisions in most theoretical and practical work. Early work analyzed and optimized linear transmitter and receiver filters subject to various criteria [5]-[11]. In this work the optimum receiver filter always turned out to be a combination of a matched filter and a transversal filter, the general reason for which is explained below.

More recently, nonlinear receivers have been investigated. Several authors [12]-[16] have developed “optimum” or approximately optimum nonlinear receiver structures, again subject to a variety of criteria. The intimidating complexity of these structures has led to interest in suboptimum nonlinear structures such as decision feedback [17], [18]. Invariably, the complaint is made that it is difficult to estimate the performance of nonlinear receivers analytically and resort is made to simulation.

Introduction (3)

1. Nature of the problem.
2. Background of previous work.
3. PURPOSE AND SIGNIFICANCE OF THE PAPER.
4. Method by which the problem is approached.
5. Organization of the paper.

(1) Intersymbol interference arises in pulse-modulation systems whenever the effects of one transmitted pulse are not allowed to die away completely before the transmission of the next.

(2) While lip service has long been paid to the idea that symbol decisions ought to be based on the entire received sequence, the fact that straightforward likelihood calculations grow exponentially with message length [4] has justified a retreat to simple symbol-by-symbol decisions in most theoretical and practical work.

(3, 4) IN THIS PAPER WE INTRODUCE A RECEIVER STRUCTURE (FIG. 2) CONSISTING OF A LINEAR FILTER, CALLED A WHITENED MATCHED FILTER, A SYMBOL RATE SAMPLER, AND A RECURSIVE NONLINEAR PROCESSOR, CALLED THE VITERBI ALGORITHM.

(3, 4) This structure is a maximum-likelihood estimator of the entire transmitted sequence; furthermore, it can be implemented and analyzed.

(5) Finally in the last section we shall describe a practical embodiment of these ideas: --.

Additional example about (5): The remainder of the paper is organized as follows. In Section II-B, we introduce - - -
Introduction (4)

- motivate and orient the reader (a simple block diagram often useful)
- show new contribution with a brief literature review (write a novelty claim: compare explicitly your results with the earlier results, what is improved?)
- define carefully the scope of the text, not too wide nor too narrow, find the right the focus
- own results are not presented in detail in the introduction
- sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page (in conference papers usually in a separate acknowledgment section) [Spectrum65]

Body of Text

Abstract
Introduction
Definitions
Discrete time model
Maximum-likelihood sequence estimation
Error events
Probability of a particular error event
Probability of error
Example: Partial response
A practical algorithm
Conclusion
Acknowledgment
Appendix I: Determining weight distributions
Appendix II: Improving SNR by preemphasis
References
Materials and Methods

• in exact sciences materials include definitions, model, and related assumptions (literature review is part of the materials)
• methods include rules of analysis and rules of verification and validation (if the methods are well known, they are briefly mentioned in the introduction)

Results (1) - reference curves

AWGN, additive white Gaussian noise
BER, bit error rate
SNR, signal-to-noise ratio
dB, decibel
Results (2)

• results can be analytical (deductive), simulation, or measurement results
• it is important to present **numerical** results that verify your own results, compare your own results for example with measurements or simulations with a reliable model (sometimes defined in standards)
• use analytical results in simple limiting cases to obtain **reference** values
• the value of the results depend on how well they can be **generalized** (bottom up approach will help you)

Conclusions (1)

1. What is shown by this work and its significance.
2. Limitations and advantages.
3. Applications of the results.
4. Recommendations for further work.

(1) We have shown that a **maximum-likelihood sequence estimator** for a PAM sequence perturbed by finite intersymbol interference and white Gaussian noise can be constructed from a whitened matched filter and the Viterbi algorithm.

(2) The **combination is simpler to implement** than previous “optimum” nonlinear algorithms and is practically feasible if the channel impulse response is not too long. --

On the theoretical side, the greatest deficiency in our results is their reliance on a finite channel response.

(3) In a practical situation, a **near optimum procedure** is to use a linear equalizer to shape the channel to some desired channel whose impulse response \( f(D) \) is short and whose spectrum is similar to the channel spectrum and then use a Viterbi algorithm that is appropriate for \( f(D) \).

(4) These results can be extended in a number of directions. **Extension to quadrature PAM**, where phase as well as amplitude is modulated, is achieved --
Acknowledgment

- mention those persons who acquired funding for your project
- mention funding organizations and projects (often even the contract number is required)
- mention those contributing persons whose contribution was not enough to select them as a co-author

Organization of the Text (1)

- **Drafting the whole text**: write a draft and try to improve it (easier for beginners)

- **Drafting table of contents**: write a very detailed outline of the table of contents and then finish the sentences
Organization of the text (2)

1. Select the type of your paper
   • Do not mix original and review papers.
2. Select the level of presentation
   • Select the right forum. Write to experts in the field.
3. Use deductive top-down (IMRAD) organization
   • Do not describe the process of learning but the final result.
   • Define your system model and related assumptions.
4. All sections and paragraphs must meet some need
   • The text must be compact and unified.
5. The text must be explicit, not implicit
   • Do not leave room for guesswork and interpretations.
   • Define all new terms, symbols, and abbreviations.

Typical mistakes in writing

• Novelty is not clearly shown.
• Writing instructions are not followed.
• Bad organization. Repetitions or gaps in reasoning.
• Standard terminology is not used. Terminology is not uniform. Not all new terms, abbreviations, and symbols are defined. Obscure abbreviations are used in titles and in the abstract.
• Grammatical mistakes (punctuation, spaces, articles, use of capital letters), spelling mistakes, long complicated sentences. British and American English is used in the same text.
• Short inaccurate comments in parentheses are used.
• Equations are not properly written. Italicization and bolding rules are not followed. Figures are inaccurately drawn.
• References are not properly used. Many references are not scientific. The author does not know the relevant references implying that no literature review has been done.
Use of References (1)

Examples:

Several authors [12]-[16] have developed “optimum” or approximately optimum nonlinear receiver structures, again subject to a variety of criteria. --- In this paper we introduce a receiver structure (Fig. 2) consisting of --- Reference [3] shows ---

Use of References (2)

- Own contribution must be clearly shown (the reader must know what was cited and what is the author’s own contribution)
- **Plagiarism** (also self-plagiarism) strictly forbidden
- Usually refer to **original** papers (in addition, you may also refer to a book or review paper to shorten the literature review)
- Give relevant page numbers for books
Journal citations [JCR05]

Electrical & Electronic Engineering, largest total cites

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Example: Conference Calendar

SOME CONFERENCE DEAD LINES AND DATES

*) even years only

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GLOBECOM
VTC Fall
VTC Spring
ICASSP
PIMRC
ISSSTA*)
Selection of Conferences and Journals

- Publish in a place where similar papers have been published earlier (check your literature review)
- Select the best possible forum (first a conference and later a journal) – in general prefer good scientific societies
- Conferences are compared with acceptance ratios (reasonable values are 30% - 45%)
- Small conferences may be more useful for finding contacts
- Journals are compared with total number of citations per article (impact factors may be misleading statistics) – new journals must be separately examined

Table of Contents for a Doctoral Thesis (monograph) [Davis97]

Abstract
Preface
Table of Contents
List of Abbreviations
List of Symbols
1. Introduction
2. Literature Review
3. Materials and Methods
4. Results
5. Discussion (may be combined with results)
6. Conclusions
References
Appendices

• Length of the thesis is about 50-200 pages
• 1665 Scientific journals
• 1675 Peer review started
• c. 1850 Methods section in use in chemistry (L. Pasteur)
• c. 1950 Peer review and IMRAD normal practices in physics
• 1965 Acronym IMRAD proposed (B. Hill)
• 1965 IEEE published its writing instructions in *IEEE Spectrum* (addition in 1966)
• 1977 TeX typesetting program (D. Knuth)
• 1979 ANSI standard *American National Standard for the Preparation of Scientific Papers for Written and Oral Presentation*, ANSI Z39.16-1979 using IMRAD structure (revision 1985, standard has been already withdrawn)
• 1986 LaTeX, a document preparation system (L. Lamport)
• 1987 Scientific electronic journal
• 1990 Scientific open access (OA) journal
• 2005 Hirsch’s h-index proposed, an index to quantify an individual’s scientific research output (J. E. Hirsch)
• 2006 Publish or Perish, a software program that analyses citations in Google Scholar using Hirsch’s h-index (A.-W. Harzing)

• Open access journals are free for readers (on the Internet), but the authors must pay a publication fee for their paper (the papers have a referee process)

---

**Conclusions (1)**

IMRAD structure of a paper

**I. Introduction**

• What question or problem was studied?

**II. Materials and Methods (Model)**

• How was the problem studied?

**III. Results**

• What were the findings?

**IV. Discussion**

• What do these findings mean?
Conclusions (2)

- Use **top-down** (deductive) approach in writing for an expert (write the thesis to an expert)
- Everything must be **explicit** and **reproducible**
- Use of terms, symbols and abbreviations must be **unified** and **defined**
- **No gaps** are allowed in reasoning, **no contradictions**
- **MOST IMPORTANT AND MOST DIFFICULT**: Give a **novelty claim** in the abstract and introduction (compare explicitly your results with the earlier results, what is improved?)
- Write a **stand-alone** document

Abbreviations

- ANSI, American National Standards Institute
- COMPENDEX, Computerized Engineering Index
- EI, Engineering Index
- IEE, Institution of Electrical Engineers
- IEEE, Institute of Electrical and Electronics Engineers
- IET, Institution of Engineering and Technology
- IEE, Institution of Incorporated Engineers
- IMRAD, introduction, methods, results, and discussion
- INSPEC, Information Services in Physics, Electrotechnology, Computers and Control
- ISI, Institute for Scientific Information
- JCR, ISI Journal Citation Reports
- SCI-Expanded, Science Citation Index – Expanded
References

- 2005 *Journal Citation Reports (JCR)*, Science Edition. Institute for Scientific Information (ISI), isi01.isiknowledge.com/portal.cgi.