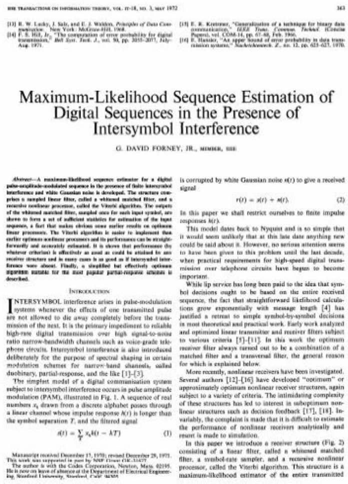
III COMPILING A SCIENTIFIC PUBLICATION ARTICLE

- Introduction
- IMRAD structure of a paper
- Organization of a paper
- Conclusions

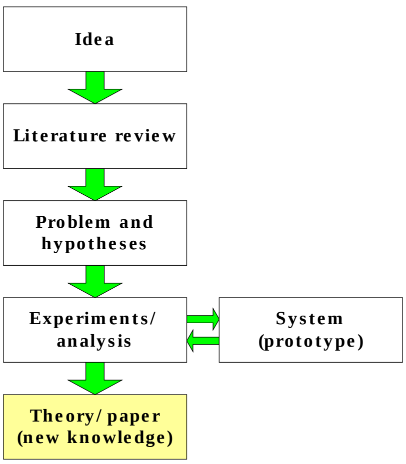


IEEE TRANSACTIONS ON INFORMATION THEORY, VOL. IT-18, NO. 3, MAY 1972

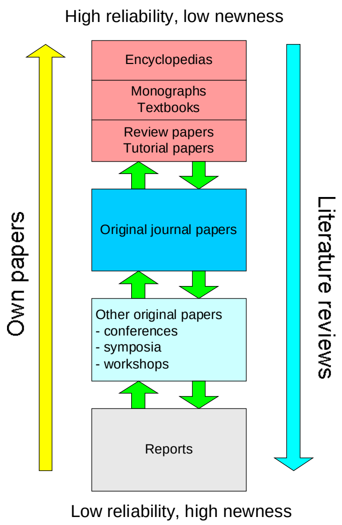
Maximum-Likelihood Sequence Estimation of Digital Sequences in the Presence of Intersymbol Interference

G. DAVID FORNEY, JR., MEMBER, IEEE

Introduction (1)



Introduction (2)

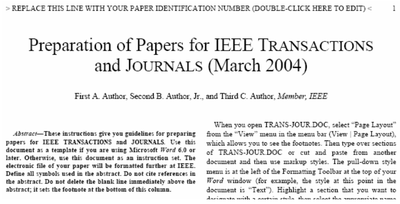


Introduction (3)

- Motivation for writing scientific papers [Sternberg, 1981]
  - distribution of knowledge
  - improves the *quality of research*
    - maturation as a researcher (our "Olympic Games")
    - improve organization, use clear definitions, accurate terminology
  - measure of scientific merit of the researcher *and* of the employer
    - peer review process
- IEEE paper is used as an example (check publisher's instructions for details)

Most important IEEE writing instructions

- *Preparation of Papers for IEEE Transactions and Journals*, www.ieee.org/organizations/pubs/transactions/information.htm
- *Preparation of papers in two-column format for proceedings submission*, www.ieee.org/organizations/pubs/confpub/auxfiles/sample_manuscript.pdf
- V. O. K. Li, 'Hints on writing technical papers and making presentations, " *IEEE Transactions on Education*, vol. 42, pp. 134-137, May 1999.
- see also the writing instructions of the journal you are interested in, www.ieee.org/organizations/tab/society.html



> REPLACE THIS LINE WITH YOUR PAPER IDENTIFICATION NUMBER (DOUBLE-CLICK HERE TO EDIT) < 1

Preparation of Papers for IEEE TRANSACTIONS and JOURNALS (March 2004)

First A. Author, Second B. Author, Jr., and Third C. Author, *Member, IEEE*

***Abstract*—These instructions give you guidelines for preparing papers for IEEE TRANSACTIONS and JOURNALS. Use this document as a template if you are using Microsoft *Word* 6.0 or later. Otherwise, use this document as an instruction set. The electronic file of your paper will be formatted further at IEEE. Define all symbols used in the abstract. Do not cite references in the abstract. Do not delete the blank line immediately above the abstract; it sets the footnote at the bottom of this column.**

When you open TRANS-JOUR.DOC, select "Page Layout" from the "View" menu in the menu bar (View | Page Layout), which allows you to see the footnotes. Then type over sections of TRANS-JOUR.DOC or cut and paste from another document and then use markup styles. The pull-down style menu is at the left of the Formatting Toolbar at the top of your *Word* window (for example, the style at this point in the document is "Text"). Highlight a section that you want to

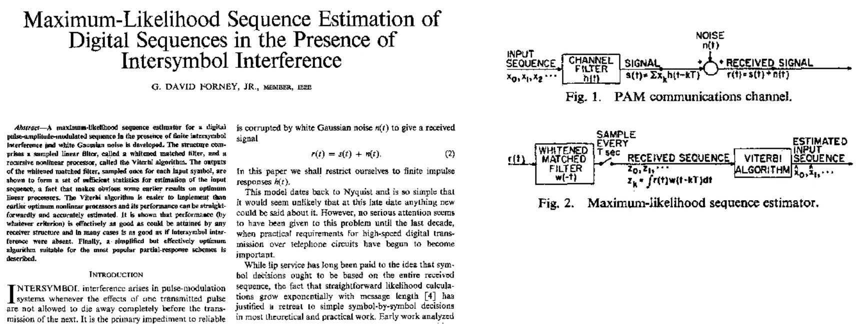
LaTeX terminology

- LaTeX (www.ctan.org, www.latex-project.org) is a document preparation system developed by L. Lamport in 1985
  - TeX is a typesetting system invented by D. E. Knuth in the 1970's (frozen in 1989)
  - LaTeX is a system for typesetting documents for the TeX and has become a lingua franca (common language) of the scientific world
  - many scientific books and journal papers are made with LaTeX, especially those which include many equations
  - the present version is LaTeX 2ε, which was published in 1993
- BibTeX is a format for bibliographies recommended by IEEE, developed by O. Patashnik and L. Lamport in 1985

Tools needed to create a LaTeX file

- For writing LaTeX documents you will need (all open source software)
  1. LaTeX itself, for example
     - MiKTeX, www.miktex.org
  2. Editor for LaTeX files, for example
     - TeXnicCenter, www.toolscenter.org
     - WinEdt, www.winedt.com
     - XEmacs, www.xemacs.org
     - Emacs, www.gnu.org/software/emacs/emacs.html
  3. Editor for BibTeX files (if not included in the LaTeX editor)
     - BibEdit, www.iui.se/staff/jonasb/bibedit
  4. LaTeX style file from the publisher, for example
     - www.ieee.org/organizations/pubs/transactions/information.htm
     - www.springeronline.com/sgw/cda/frontpage/0,11855,5-164-2-72376-0,00.html
  5. LaTeX guide, for example
     - *The not so short introduction to the LaTeX 2ε*, www.ctan.org/tex-archive/info/lshort/english/lshort.pdf, Finnish version ftp://tug.ctan.org/pub/tex-archive/info/lshort/finnish/lyhyt2e.pdf

Example original paper



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

G. DAVID FORNEY, JR., MEMBER, IEEE

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.

INTRODUCTION

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

is corrupted by white Gaussian noise $n(t)$ to give a received signal

$$r(t) = s(t) + n(t). \quad (2)$$

In this paper we shall restrict ourselves to finite impulse responses $h(t)$.

This model dates back to Nyquist and is so simple that it would seem unlikely that at this late date anything new could be said about it. However, no serious attention seems to have been given to this problem until the last decade, when practical requirements for high-speed digital transmission over telephone circuits have begun to become important.

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

Fig. 1. PAM communications channel.

Fig. 2. Maximum-likelihood sequence estimator.

- Examples are from G. D. Forney, Jr., "Maximum-likelihood sequence estimation of digital sequences in the presence of intersymbol interference," *IEEE Transactions on Information Theory*, vol. IT-18, pp. 363-378, May 1972.

IMRAD structure of a paper [Day, 1998]

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 [*IEEE Spectrum*, 1965]

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.

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.

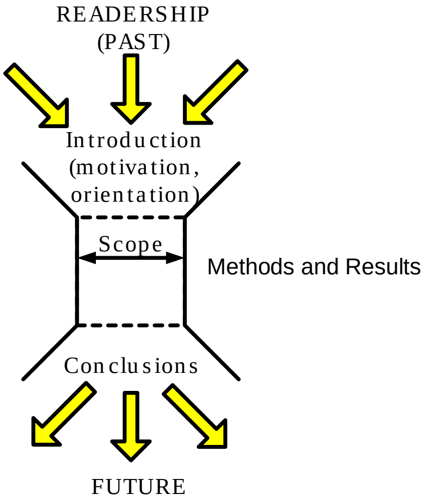
II. System model (Materials and methods)

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.

Structure of an IEEE paper (2) [*IEEE Spectrum*, 1965], [Day, 1998], [Engeström, 1984]



Title and list of authors [*IEEE Spectrum*, 1965]

- Title
  - not too general
  - brief, clear and descriptive
  - less than ten words
- List of authors
  - at most four or five names recommended
  - include those who had *scientific contribution* (those who solved engineering problems)
  - the order of the names reflect the significance of the contribution (first name most important)

Abstract (1)

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.

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

Abstract – (1, 2) 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. (3) 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. (4) The Viterbi algorithm is easier to implement than earlier optimum nonlinear processors and its performance can be straightforwardly and accurately estimated. (3) 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. (2) Finally, a simplified but effectively optimum algorithm suitable for the most popular partial-response schemes is described.

Abstract (2) [IEEE Spectrum, 1965, 1966]

- length usually limited to 50-200 words plus a few key words (in conference papers typically 150 words)
- the first sentence establishes the context and scope of the paper
- identify important ideas: make it *informative*, not merely a list of topics
- must be understandable independently: no references to the paper, no citations, no obscure abbreviations, include only information mentioned in other parts of the paper
- author's own contribution must be emphasized
- below the abstract, give about four key words or phrases in alphabetical order

Introduction (1)

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

G. DAVID FORNEY, JR., MEMBER, IEEE

INTRODUCTION

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_k drawn from a discrete alphabet passes through a linear channel whose impulse response $h(t)$ is longer than the symbol separation T, and the filtered signal

$$s(t) = \sum_k x_k h(t - kT) \qquad (1)$$

Manuscript received December 17, 1970; revised December 29, 1971. This work was supported in part by NSF Grant GK-31627.
The author is with the Codex Corporation, Newton, Mass. 02195. He is now on leave of absence at the Department of Electrical Engineering, Stanford University, Stanford, Calif. 94305.

VTT TECHNICAL RESEARCH CENTRE OF FINLAND

Introduction (2)

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

G. DAVID FORNEY, JR., MEMBER, IEEE

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, 5) 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* (compare your results with the earlier results, what is improved?)
- define carefully the *scope* of the text, not too wide nor too narrow, remember *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 often in a separate acknowledgment section)

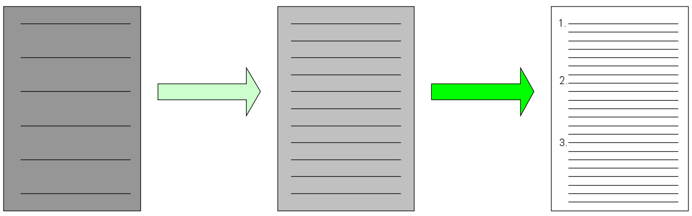
Body of the text

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

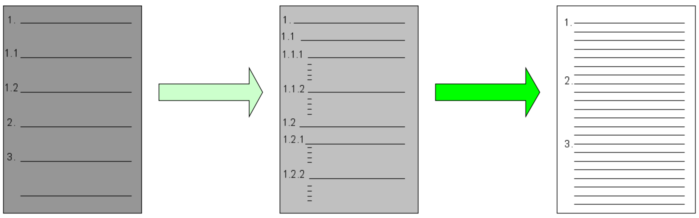
VTT TECHNICAL RESEARCH CENTRE OF FINLAND

Organization of the text (1) [Phillips, 2000]

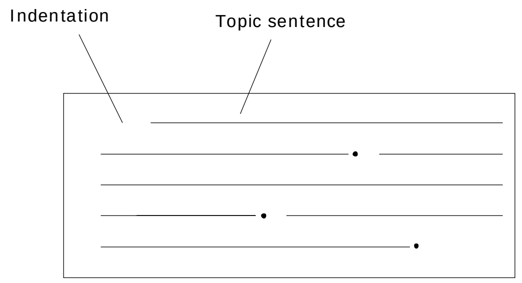
• *holistic approach*: write a draft and try to improve it



• *serial approach*: write a very detailed outline of the table of contents and then finish the sentences



Organization of the text (2) [Young, 2002]



- Do not use very short or very long paragraphs, do not use very long complex sentences
- Start a paragraph with a topic sentence or some other indication of the subject
- Divide long text sections into smaller parts with headings

Organization of the text (3)

- study the material and use key words for outlining (a *mind map* may also be useful, www.mind-map.com)
- describe assumptions, system model, analytical, numerical or experimental results
- define your system model, no silent assumptions allowed, everything must be *explicit* and *deductive* (top down approach) with some numerical examples
- treat each topic in one place only, minimize cross-references to other parts
- try to make the organization clear, unified and well balanced, no repetitions, no gaps between sections, write a stand-alone document

Organization of the text (4)

- use of terms, symbols and abbreviations must be *unified* during outlining, do not use different synonymous terms, define all symbols, abbreviations and new terms
- continue outlining until all the topics are covered and well organized
- make a list of figures and tables, use them sparingly
- based on the outline, write a table of contents (make a clear copy!)

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.

CONCLUSION

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. The combination is simpler to implement than previous "optimum" nonlinear algorithms and is practically feasible if the channel impulse response is not too long. Its performance can be accurately estimated and is shown to be effectively as good as can be attained by any estimator, regardless of the criterion of optimality. Furthermore, in

(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 $f(D)$.

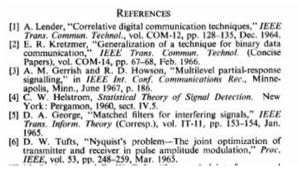
(4) These results can be extended in a number of directions. Extension to quadrature PAM, where phase as well as amplitude is modulated, is achieved --

Conclusions (2)

- Conclusions are a brief summary and discussion
- You can make things concrete by emphasizing
  - limitations (show the scope)
  - advantages (what is better than previously)
  - applications (where this result can be used)

VTT TECHNICAL RESEARCH CENTRE OF FINLAND

References (1)



REFERENCES

[1] A. Lender, "Correlative digital communication techniques," *IEEE Trans. Commun. Technol.*, vol. COM-12, pp. 128–135, Dec. 1964.
[2] E. R. Kretzmer, "Generalization of a technique for binary data communication," *IEEE Trans. Commun. Technol.* (Concise Papers), vol. COM-14, pp. 67–68, Feb. 1966.
[3] A. M. Gerrish and R. D. Howson, "Multilevel partial-response signalling," in *IEEE Int. Conf. Communications Rec.*, Minneapolis, Minn., June 1967, p. 186.
[4] C. W. Helstrom, *Statistical Theory of Signal Detection.* New York: Pergamon, 1960, sect. IV.5.
[5] D. A. George, "Matched filters for interfering signals," *IEEE Trans. Inform. Theory* (Corresp.), vol. IT-11, pp. 153–154, Jan. 1965.
[6] D. W. Tufts, "Nyquist's problem—The joint optimization of transmitter and receiver in pulse amplitude modulation," *Proc. IEEE*, vol. 53, pp. 248–259, Mar. 1965.

Original journal paper

[1] A. Lender, "Correlative digital communication techniques," *IEEE Trans. Commun. Technol.*, vol. COM-12, pp. 128-135, Dec. 1964.

Original conference paper

[27] D. B. Payne and J. R. Stern, "Wavelength-switched passively coupled single-mode optical network," in *Proc. IOOC-ECOC 85*, 1985, p. 585.

Book

[4] C. W. Helstrom, *Statistical Theory of Signal Detection*. New York: Pergamon, 1960.

References (2)

- Own contribution must be clearly shown
- 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

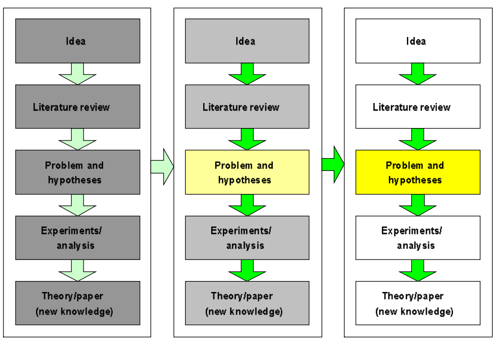
Examples on how to refer to the reference list:

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 ---

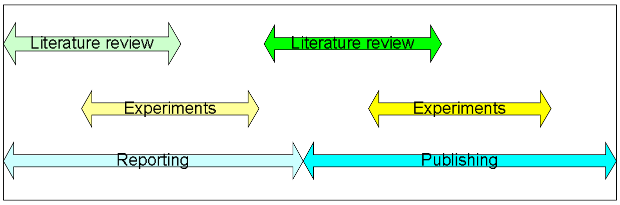
Reference [3] shows ---

VTT TECHNICAL RESEARCH CENTRE OF FINLAND

Conclusions – generative research method (1)

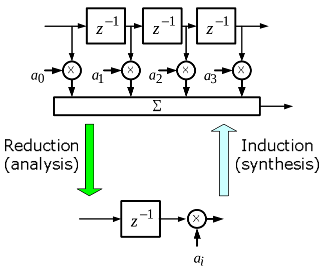


Conclusions – generative research method (2)



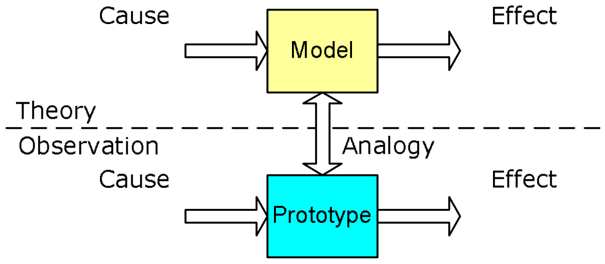
- You must work iteratively since the problem and hypotheses are initially not very clear (a chicken and egg situation)
- In the beginning it is difficult to understand the literature
- Experience is gained by own experiments and discussions
- Reporting and publishing will improve the quality of research

Conclusions – reductive approach



- Break the problem down and then generalize the results (”strip and reassemble ”, ”pura ja kokoa ”)
  - ”Practical people often balk at this approach [reduction, idealizations] since the idealized situations may be so far removed from those of use as to appear highly academic. ” [Wilson, 1990]
- We present the results explicitly by deduction (top down), but we learn through induction (bottom up)

Conclusions – theory and practice



- A good research project emphasizes theoretical results (usually system models) and uses prototypes for verification and validation of the *new* results

Conclusions – general hints

- Define and redefine your *problem* and competing *hypotheses*
- Use *bibliographies* to improve your efficiency in literature reviews, learn the *terminology*, write a *classification* or taxonomy for the state of the art, and see historical trends
- Use *reduction and induction*: start from very simple models and generalize, make simple experiments early in your project
  - use *block diagrams* to improve your understanding
  - be *rigorous,* use reference results (probably idealistic upper and lower bounds), use confidence intervals for statistical results, compare your results with earlier results in the literature,
  - improve your *communications* abilities, discuss with your colleagues, respect criticism, listen to what is said to you (do not behave like a bull in a china shop)
- Start to *outline* the paper right from the beginning (there will never be ”more time”), emphasize good *organization*
- Reserve time for all phases in your project plan

References

- D. Sternberg, *How to Complete and Survive a Doctorial Dissertation*. New York: St. Martin's Press, 1981.
- R. A. Day, *How to Write and Publish a Scientific Paper*, 5th ed. Oryx Press, 1998.
- "Information for IEEE authors," *IEEE Spectrum*, pp. 111-115, Aug. 1965.
- "A supplement to 'Information to IEEE authors'," *IEEE Spectrum*, p. 91, May 1966.
- Y. Engeström, *Perustietoa opetuksesta*, 2nd ed. Valtiovarainministeriö, 1984.
- E. M. Phillips and D. S. Pugh, *How to Get a PhD: A Handbook for Students and Their Supervisors*, 3rd ed. Buckingham: Open University Press, 2000.
- E. B. Wilson, Jr., *An Introduction to Scientific Research*. New York: Dover Publications, 1990, p. 36.
- M. Young, *The Technical Writer's Handbook: Writing with Clarity*. University Science Books, 2002

Bibliography (additions)

- Institute of Navigation (ION), www.ion.org
- International Council on Systems Engineering (INCOSE), www.incose.org
- Glossary of Systems Engineering (SE) Terms, www.seecforum.unisa.edu.au/glossary
- National Electronic Library Interface, www.nelliportaali.fi
- Finnish municipal libraries, www.kirjasto.fi
- Book stores, additional example
  - chapters.indigo.ca, www.chapters.com
- Application notes, for example
  - Hewlett-Packard, www.hp.com
  - Tektronix, www.tektronix.com
  - Intel, www.intel.com
  - National Semiconductor, www.national.com
  - Texas Instruments, www.texasinstruments.com