Scientific Writing*

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1 Preface

You may have difficulty writing, or you may have heard from professors or reviewers that your writing is hard to follow. Or you may have studied writing only in the context of literature, and have trouble translating your skills into a technical setting. Enough students have these difficulties.

This booklet explains how to study technical writing in the context of a weekly group. If nothing else, a group will show you that you are not alone in your difficulties. Problems you may have are problems that others also have, and you can find similar problems even in published papers. But we do not emphasize problems; instead we emphasize useful principles and practices that you can learn to apply to your own manuscripts.

- I like to emphasize principles that can be applied successfully by a beginning writer. Especially for students in science and engineering, a principle is easily applicable when there is a simple, experimental way to decide if the written words obey the principle. For example, I have a hard time to teach students to 'omit needless words,' because I know of no simple way to decide if a word is needless. In this approach, I follow the ideas presented by Norman Ramsey [1] and by Joseph Williams [3].

- I like to emphasize practices that have been shown, again by experiment, to lead to productive writing. For example, I explain the difference between binge writing and brief, daily sessions. In this approach, I follow the advices given by Robert Boice [2].

What both approaches have in common is that even a beginner can apply a simple test to see whether he or she is applying a given principle or following a given practice. I hope this engineering focus on testable ideas will help you with your writing.

*adapted from Norman Ramsey, Harvard University

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2 Why a group and what might happen

Compared with individual instruction, a writing group is not only more comfortable but also more effective. The focus is not relentlessly on your own writing. You see other writing at your own level as well as professional writing. In this context, you can evaluate the utility of the principles we teach and decide for yourself what does and does not work. Engineering is all about carefully evaluating techniques to see what works in practice, and you can apply that attitude to writing.

A group also helps because it is easier to learn to improve other people's writing before trying to apply the same principles to your own writing. You will also learn when your work is read by the group. It is invaluable simply to sit back and see where readers do not understand; miss the point; or feel distracted, bored, or confused. One reader's reaction might be idiosyncratic, but when a whole group of readers reacts the same way, it is easier to accept that the flaw might lie in the text.

The rest of this section gives a short overview of the material you may study in the group, as well as some things you can expect to happen.

2.1 Techniques for study

The primary purpose of this group is to learn good technique, as summarized by the principles and practices (shown later). A principle describes some property of a text; I try hard to phrase each principle so that you can easily decide whether a particular text respects it. You can then evaluate the hypothesis that a text which respects the principle produces a better effect in the reader's mind.

The practices focus not on properties of texts but on the means by which texts are produced. A practice recommends a behavior that, when followed by the writer, can lead to more fluent and successful production. It is unfortunately quite difficult for a single student to evaluate which practices make a difference, but you may get a chance to read about and discuss some of Robert Boice's [2] controlled experiments, which are quite convincing.

2.2 Expected outcomes

Groups vary, but there are certain things you can expect to happen:

- You can expect your writing to improve, and perhaps to come more easily. Some of the exercises in Section 3.2 are simple enough that you will see results immediately.

- You will learn a few principles, and you will learn to apply those principles, but you will probably find it easier to apply them to others' work repeatedly before you can apply them to your own work.

- In a 90-minute meeting, you will be able to discuss a surprisingly small amount of text. Don't be disappointed; a narrow focus(even just a few sentences!) often yields the deepest insights.

- Even when the focus is very narrow, discussions will often be great fun.

- Your first meetings will probably focus on mechanics. But after a month or two, you can expect discussions of mechanics to lead to discussions of ideas. As your group gains experience, you will move more often (and more quickly) towards ideas.

- Most of the time,you will probably prefer texts which respect the principles in Section 3.1. But you may encounter one notable exception: there are texts that readers like, but that completely disregard Williams's advice about subjects and verbs(Principle3). Such texts tend to be technical description, in which it is hard to identify any real actions taking place.

- You will be able to learn a lot about writing in two hours per week; you should be able to leave each meeting feeling you understand something significant about your own and others' writing.

- In a semester, you will probably find it difficult to learn more than just 2 or 3 principles or practices and even that much will be hard work. But if you really internalize 2 or 3 useful principles and consistently apply them to your own work, you will be impressed at how much better your writing gets.

3 Mechanics and pragmatics

3.1 Expectations: preparation and meeting

Our goal is to teach technical writing in two hours per week: half an hour of preparation and an hour and a half of meeting. (Experienced students really do prepare in half an hour, but beginning students spend more time both on exercises and on supplementary reading.) Attending the meetings is important; unlike other kinds of knowledge, which can be acquired independently from a text or by listening to a taped lecture, writing can really only be learned by doing and by getting feedback. If you don't show up, you learn nothing, and if you don't comment on others' work, it's unfair for you to benefit from others' reading of your own work.

Meetings about principles Most meetings will focus on principles of clear writing. A meeting focused on a principle will probably be organized around an exercise that you will have completed before the meeting. Each exercise requires analysis, and sometimes revision, of a sample text written by a student author or by a professional. A typical exercise focuses on just a few paragraphs, or at most a section. The exercises might remind you of problem sets, except that because they often call upon you to evaluate events that happen in a reader's mind, not everyone will agree on the answers.

Meetings about practices Some meetings will focus on practices of successful writers. A meeting focused on a practice will probably be organized as a discussion of some reading. The discussion may resemble discussions in graduate seminars. The most effective discussions analyze how the ideas in a reading might apply to your own writing practices.

Early meetings For the first few meetings, I like to analyze professional papers. Such papers provide a good platform for testing our principles scientifically: Do the writers we like respect our principles? With what effects in the minds of the readers? I will enlist your help by inviting you to bring examples of published papers you like and dislike.

3.2 Commenting on a text

A key part of our approach is to ensure that group members' comments support empirical evaluation of a text. Here are some examples of useful comments:

- 'I believe that the most important idea in the paper is the idea of using a finite automat onto model the infinite space of possible signatures.'
- 'At the end of paragraph A, I was happy, but but the time I got to sentence 3 of paragraph B, where it says that a machine register has a weight that is equal to the number of resources it consumes, I felt that I no longer understood what was going on.'
- 'I don't understand the distinction between an 'argument' and a 'parameter'.'

Each of these examples provides evidence of important events happening in the reader's mind, and two of them tie those events to specific words or locations in the text.

An example of a less useful comment is 'the third section is not well written.' The comment is about the text, not about what is in the reader's mind, and it is not focused on any particular part of the text.

When your paper is being discussed, we may ask you not to speak. In part, we do this to be sure that any comments are made in response not to you but to the words on the page. In part,

we do it to mimic the process of professional reviewing; after all, when you send a paper out for review, you can't enter into a discussion to explain what you really meant. And in part, we do it to give you space to focus your full attention on what your readers are saying, without being distracted by thinking about how to formulate a response. You'll get a chance to talk at the end of the session.

When your text is being discussed, we encourage you to take notes. It is surprisingly difficult to remember what is said; no matter how sympathetic the group and how mature the author, there is something intense and sensitive about having one's work discussed. The intensity of the experience can make it hard to hear and remember everything as it is being said. If your group members agree, you may even wish to use a microphone to record discussions, especially if you are getting comments on a paper that you will soon submit.

4 Principles, practices, exercises, and guidelines

This section sets forth what you will actually study: principles, practices, and guidelines for successful writers, together with exercises that will help you master the principles. I introduce them with short explanations of the thinking behind them, but neither the principles nor the practices are self-explanatory. Explanations can be found in [3] in [2] and also in the exercises.

4.1 Principles and practices for technical writers

Principles A principle is useful only if a beginning writer can test to see if a text obeys it. Here are some examples of principles that are difficult to test for (all real advice from real writers):

- Omit needless words.
- Pay attention to the rhythm of the paragraph.
- Group ideas into sentences in the most logical way.

Here are some principles that are easier to test for:

- The agents and actions that you want to appear most important in the mind of your reader should be used as the subjects and verbs of your sentences.
- The old information in a sentence should appear at the beginning, and the new information should appear at the end.
- Don't use different words to mean the same thing, especially for technical terms. For example,don't use both 'stack frame'and 'activation record.'
- In technical text especially, prefer singular to plural. For example, in the sentence 'lexical analyzers translate regular expressions into non deterministic finite automata,' how will you know if a single lexical analyzer translates one expression or many? Singular is clearer.

By using testable principles, we stay within the educational culture of science: to reach principle, you can test the hypothesis that applying the principle makes writing clearer.

The principles listed below are organized more or less by scale; in general, earlier principles apply to smaller parts of a manuscript. I have starred principles that I consider especially valuable.

Practices It's surprising how many books on writing talk only about the words on the page and not about what the writer is actually doing how the writer behaves. These books are missing many important questions: Where do you write? When? How often? For how long? With what goals? How do you know when to stop? How do you think about writing? The answers to these questions affect not only your attitudes but also the amount and quality of the text you produce. Some of the research is astonishing [2].

I call useful behaviors practices. Good practices are all about changing your behavior, which in turn can change your attitude, which in turn can change behavior, and so on in a virtuous cycle. Writing practices are highly personal, and the role of the writing group is not to prescribe given practices but to help you discover which ones are best for you. At one time or another, I have found each of the practices helpful, but my two favorites are to write in brief daily sessions(Practice 1) and to plan and revise using index cards(Practice 4). Use the group to discover your own favorites.

The practices listed below are organized more or less by readiness; in general, earlier practices apply to manuscripts in earlier stages of being written. (Indeed, Practices 2, 3, and 4 apply primarily to manuscripts that have not yet begun to be written.) The exception is Practice 1, which applies to work at all stages. I have starred Practice 1 because of its singular importance and Practice 5 because my students consistently have great difficulty writing first drafts.

Principles and practices of successful writers

- Principles

    1. Correctness. Write correct English, but know that you have more latitude than your high-school English teachers may have given you. You find good advice on correct English in [4].
    2. Consistent names. Refer to each significant character(algorithm, concept, language) using the same word everywhere. Give a significant new character a proper name.
    3. Singular. To distinguish one-to-one relationships from n-to-m relationships, refer to each item in the singular, not the plural.
    4. Subjects and verbs. Put your important characters in subjects,and join each subject to a verb that expresses a significant action.
    5. Information flow. In each sentence, move your reader from familiar information to new information.
    6. Emphasis. For material you want to carry weight or be remembered, use the end of a sentence.
    7. Coherence.In a coherent passage, choose subjects that refer to a consistent set of related concepts.
    8. Parallel structure. Order your text so your reader can easily see how related concepts are different and how they are similar.
    9. Abstract. In an abstract, don't enumerate a list of topics covered; instead, convey the essential information found in your paper.

- Practices

    1. Write in brief daily sessions. Ignore the common myth that successful writing requires large, uninterrupted blocks of time instead, practice writing in brief, daily sessions.
    2. Focus on the process, not the product. Don't worry about the size or quality of your output; instead, reward yourself for the consistency and regularity of your input.

3. Prewrite. Don't be afraid to think before you write, or even jot down notes, diagrams,and so on.
4. Use index cards. Use them to plan a draft or to organize or reorganize a large unit like a section or chapter.
5. Write a Shitty First Draft . Value a first draft not because it's great but because it's there.
6. Don't worry about page limits. Write the paper you want, then cut it down to size.
7. Cut. Plan a revision session in which your only goal is to cut.

4.2 Exercises

The exercises below comprise most of what we do in my writing groups. Almost every exercise is designed to teach one of the principles in Table 1; an important exception is Exercise G, which although valuable, does not come with an articulated principle. Not all exercises are equally good; among the best are Exercises A, C, and G, which you can profitably do repeatedly.

The exercises are listed in an order in which it may be useful to do them.

Exercise A: Agents and actions This exercise is based on Chapter 2 of Williams's Style: Toward Clarity and Grace. The big lesson from Chapter 2 is this: if you have certain ideas in your head about what agents and actions are most important,you will communicate those ideas most clearly if you make those agents and actions the subjects and verbs in your sentences. To help you learn how to apply this principle, here is an exercise in three parts.

The first part is about the ideas that form in your head as you read, not about the words on the page. Take the text, and as you read each paragraph, identify

- The important characters in the story
- The actions taken by those characters

Use your own words to identify the characters and their actions, not necessarily the words in the text. You will probably find it easiest to take notes in the margin or on another sheet of paper.

The second part is to go through the text again. Make a distinctive mark on the main subject and verb of each sentence. (I like to underline the subject and double-underline the verb.)

The third part is to make comparisons. How consistent are the important characters and actions with the subjects and verbs used in the text? If you felt good about the text and enjoyed reading it, did you find that the characters and actions were consistent with the subjects and verbs? If you didn't enjoy the text,did you find that the characters and actions were inconsistent with the subjects and verbs?

Exercise B: Diction Sometimes it can be hard to work with agents and actions because the agents or actions are difficult to identify by name. Writing about research in computing can be especially difficult because there are so many new things for which there are no established names. To help with these problems,here are the three parts of Principle 1(Consistent names)[1]

1. Give it a name. Some writers try to dodge the issue by carefully avoiding naming things. Saying 'our language,' 'the prototype system,' or 'the algorithm' doesn't do the job. Do your reader a favor and give your language,your system, or your algorithm a name.

[1] All the examples are from papers we have discussed in my group.

2. When you are talking about one idea, always use the same word or phrase. For example, don't call your idea 'data dispersal' in one place and 'revealing secrets' in another.

3. When you are talking about different ideas, never use the same word. For example,don't use the word 'system'to talk about a model, an algorithm, and a software artifact.

The exercise is to scrutinize a manuscript and identify places where names are misused or an important thing is unnamed. Reduce the number of names as needed, and choose effective names for each concept, agent, action, and object.

Exercise C: Old and new information This exercise is based on material from Chapter 3 of Williams's Style: Toward Clarity and Grace. The idea is to make text easier to read by considering the flow of information from one sentence to the next sentence within a paragraph. Williams argues that information flows best when old information is at the beginning and new information is at the end.

To learn how to apply this principle, here is an exercise in two parts.

1. The first part is to go through the text and mark the old and new in-formation in each sentence. I usually mark with a dotted underline for old information and a solid underline for new information,but you should mark using a system that works for you.

2. The second part is to identify one or two sentences that you would like to revise based on information flow, and to suggest a revision for each.

Exercise D: Important information You may have difficulty identifying old and new information in Exercise C. A useful simplification is simply to mark the most important (new) information in each sentence. Discussion can proceed based on how many sentences place the most important information at the end or how sentences might be revised by moving the most important information to the end.

ExerciseE:CoherentsubjectsThisexerciseisalsobasedonmaterialfrom Chapter 3 of Williams's Style: Toward Clarity and Grace. The idea is to make a paragraph feel more coherent by considering the string of topics within the paragraph(Williams1995,page56).

To learn how to apply this principle, here is an exercise in two parts.

1. Go through a paragraph and underline the first five or six words of each sentence.

2. Study the topics for coherence. First, eliminate every outlier that simply refers to information from the end of the preceding sentence. Do the remaining topics seem to form a coherent sequence? If not,please suggest a sequence of topics you like better, then revise each sentence as needed to move the suggested topic to the beginning of the sentence.

Exercise F: Quick start Underline the first seven or eight words of each sentence. If the underlined portion does not contain an agent as subject and an action as verb, that sentence is a candidate for revision.

Exercise G: Structure of a section This exercise can help you with the structure of a section in a conference or journal paper or with the structure of a chapter in a thesis. The preparation is simple: each member of the writing group reads each paragraph of the section or chapter and answers two questions.

1. What is the purpose of this paragraph?

2. How well does it fulfill its purpose?

The first question is more important than the second. The hard part is distinguishing the purpose of a paragraph from the content of that paragraph. Roughly speaking, content is what a paragraph is about, while purpose usually has to do with causing an event to happen in a reader's mind. The group meeting needs a skilled moderator who can keep the group focused on purpose.

The fun comes in the meeting. The author is not allowed to say anything. Instead, the text has to speak for itself. The writing-group moderator will help the group form its collective impressions of the paragraphs. You can expect a lot from this exercise.

- It can be eye-opening for the author to learn how others read the text.
- It can let the author know how successful the section is in general.
- It can identify several kinds of structural problems
  - Paragraphs that try to serve two or three purposes at once
  - Paragraphs the purpose of which is not obvious
  - Introductory material at the end of the section
  - Paragraphs serving the same purpose that are widely separated in the text
  - Redundant paragraphs

  There's generally no need to try to identify such problems in advance; these identifications emerge naturally from the discussion.

We've used this exercise successfully with sections of 10-20 paragraphs.

After doing this exercise, it may be helpful to use a deck of index cards to reorganize the section(Practice4).

Exercise H: Parallel structure Much of scientific writing is about making comparisons. When two or more complex things are compared, a reader can follow more easily if the comparison uses parallel structure. Because more than one parallel structure is possible, part of the writer's job is to identify an effective one.

The exercise proceeds as follows:

- Begin with a piece of scientific writing in which two or more alternatives are compared.
- Break each alternative down into its atomic elements. (The choice of what elements are considered atomic is up to the author.)
- For each atomic element in each alternative, consider how it relates to elements in other alternatives. There are three possibilities.
  1. Elements are parallel because they are the same in multiple alternatives. For example, both XEmacs and GNU Emacs are free software released under the Gnu Public License.
  2. Elements are parallel because although they are not the same, they are directly comparable; e.g., you have to choose among them. For example, XEmacs draws the screen by using the Xt toolkit, whereas GNU Emacs uses the X protocol directly and can work without a toolkit.
  3. Elements in one alternative have no parallel in another alternative. For example,GNU Emacs iscontrolled by Richard Stallman, who is a well-known, controversial figure. No person of similar characteristics is associated with XEmacs.

- Finally, and most difficult, choose a single structure that can be used to describe each of the alternatives, such that parallel elements appear in corresponding places in each description.

Identifying parallel and non-parallel elements can be done outside of group, but choosing a good parallel structure is best done during the group meeting.

Exercise I: Singularity A common fault in computer-science writing is to use plural everywhere. In technical text especially, prefer singular to plural. For example, in the sentence 'lexical analyzers translate regular expressions into nondeterministic finite automata,' how will you know if a single lexical analyzer translates one expression or many? Singular is clearer.

The exercise is to tackle several paragraphs and eliminate as many plurals as possible(without changing the meaning of the text).

Exercise J: Cutting Many professional papers are limited to a fixed number of pages. To produce a paper within the limit, it is sometimes necessary to write a longer paper and then cut. Because it is so difficult to cut your own work, we suggest practicing cutting on someone else's work. It might be useful to experiment with cutting a section to 34 or even 21 of its original length.

Start this exercise with a section in which each paragraph has been labeled with its purpose, as in Exercise G. Use this information to decide how many jobs the section does within the paper as a whole. Based on this decision, cut in one of two ways:

1. If the section does multiple jobs, perhaps one or more of those jobs can be eliminated. In this case, identify the paragraphs doing the work, and cut those paragraphs.

2. Perhaps the section does only one job, or perhaps each of the jobs it does is essential. In this case,assign a relative value of each paragraph; an easy measure of value would be the ABC scale. Now cut the C paragraphs, followed by as many of the B paragraphs as needed to reach your length goals.

Make these kinds of cuts, repeating if necessary, until the text is at or just under the target length. Now re-examine and rewrite the section to be sure that it is still coherent, that transitions make sense, and so on. If this rewriting pushes you over the length limit, go back and cut again.

When cutting a technical paper,it is tempting to keep all the 'real content' and to remove motivation and examples. Resist this temptation.

Exercise K: Writing the abstract Writing a scientific abstract is a specialized art. To practice this art, follow the advice given by Landes(1966): make sure the abstract includes the essential information presented in the paper.

To prepare for the exercise, the group leader should take a technical paper and remove the abstract. Since this is one of the few exercises for which group members will have to read an entire paper,it helps if the paper is well written, easy, and of interest to most members of the group.

The exercise has two parts:

1. To prepare for writing group, read the paper and mark those points that you think constitute the 'essential information' that should be conveyed in the abstract. Highlight, make a list, or do whatever works for you.

2. In group,we will attempt to prepare abstracts at two of the more common lengths: 200 words and 50 words. As time permits we may also try 300 or100 words. If you are motivated to write an abstract ahead of time,by all means do so.

If you are pressed for time and cannot read the whole paper, you may do almost as well by abstracting what you find in the introduction and conclusion.

Our experience is that an interesting paper usually requires two 121 -hour sessions: In the first session, we agree on what constitutes the essential information in the paper. In the second session, we write abstracts. Because the actual writing requires that we choose suitable subjects and verbs and manage the flow of information well, it helps to do this exercise after you can apply these techniques successfully.

4.3 Supplementary guidelines

We have developed some useful guidelines that we do not yet know how to turn into crisp principles or exercises.

Guideline 1: Explaining a technical concept Science and engineering often involve explaining new concepts. To help decide if the explanation of a new concept is adequate, here are some questions:

- Have I enumerated all the properties of the thing?
- Have I said whether the thing is completely characterized by those properties?
- Does each property have a name?
- If mathematical, does each property have a symbol?
- Have I said what kind of value each property is? (Integer, real number, string, symbolic expression, list, tree, graph, etc etc)
- Have I explained relationships that hold among the properties? Who or what guarantees that these relationships hold?

Guideline 2: Checklist for technical exposition Here are some ideas, questions, and techniques we have found helpful when planning, organizing, and assessing a paper as a whole. Some of these ideas apply only to computer science.

- Have you identified the target audience?
- Have you told your reader what you expect? For example, should he or she just understand high-level ideas, or is it important to get all the details? What should a reader take away? For example, should your reader be led to draw a conclusion? Acquire a new skill?
- Do you have examples? They are helpful, and they should
  - Be plentiful.
  - Use parallel structure
  - Be connected to each other when possible
- An ideal, when possible, is to use a single running example that appears in each section of the manuscript. (It maybe supplemented by additional examples.)
- Is every general, abstract declaration illustrated by an example? For ex-ample, is a declaration such as 'A constructor is used at compile time to build an abstraction' illustrated by an example such as 'for example, a compiler might use the constructor gbind to build an environment that binds main to a procedure.'?

Computer scientists often create artifacts that are too complex to be easily described. Here are some notes for presenting complicated technical abstractions:

- You may well have a nest of interrelated concepts for which there is no obvious order of presentation. To come up with an order, you may have to tell lies, i.e., make simplifications for pedagogical purposes. Such simplifications should be announced. For example,you could claim for pedagogical purposes that a variable stands for a number, not a location.

  Another technique is to mention a concept without defining it. For example,you might say 'Let's assume that l is a location on the stack, without going into the details, which are in Section 12.'

  Checklist:Is every concept mentioned before it is used? Are most concepts defined before use?

- Types help. Do you give the type of every operation?

- Do you explain the name of each variable? Do you explain what each Greek letter may stand for? For example, do you explain that stands for an environment?

- When presenting abstract data types, we are aware of two styles. Hoare's style talks about the abstraction represented by a type and explains the concrete operations by their effects on the abstraction. For example, Hoare might explain an environment by using the abstraction of a set of bindings, and he might explain lookup by finding a binding with a given left-hand side.

  Algebraic or equational style gives equations that relate concrete operations on the type. Equations can usually be turned into a term-rewriting system that can specify results returned by observers. For example, algebraic style might rewrite a lookup operation into the value looked up(by substituting equals for equals at every step).

  Checklist: Do you know what style you are using? Are your definitions and examples all consistent with that style? Do you wish to use both styles? If so,have you explained the redundancy to your reader?

References

[1] Norman Ramsey. Learn Technical Writing in Two Hours per Week. Course Notes, Harvard University. 2006.

[2] Robert Boice. Advice for New Faculty Members. Allyn & Bacon. 2000.

[3] Joseph Williams. Style: Toward Clarity and Grace.University of Chicago Press. 1995.

[4] W.J. Strunk, E.B. White. Elements of Style. Tandem Library. 1999.

[5] Donald E. Knuth, Tracy Larrabee, and Paul M. Roberts. Mathematical Writing. Course Notes. Stanford University.

Paragraph A (1) One solution to this problem and related problems associated with the impact of large trades is the use of so-called "upstairs markets" in which broker/dealers shop around large orders to others without revealing the details of the transaction to the public. (2) Market makers conduct large transactions by mutual agreement, often at a discount to the prevailing market price, without having to use the more obvious "downstairs markets." (3) Both upstairs and downstairs markets suffer from the problem of "front-running," in which someone who knows about an upcoming order is able to execute a trade that takes advantage of that knowledge. (4) Sometimes, this is illegal, when the front-running is based on inside information; in other cases, it is merely parasitic, when one trader recognizes the habits of another trader or sees an incoming large order and is able to act quickly to place a trade before it hits the marketplace. (5) Quite recently, important market businesses have been investigated and charged with violations of SEC regulations due to illegal front-running practices.

Paragraph B (1) In upstairs markets, trading large blocks of stock can take more time and is more prone to negotiation; fewer participants are able to evaluate the transactions. (2) This ultimately may lead to less competitive prices for those buying or selling. (3) Our solution to this problem is the use of a homomorphic encryption scheme, similar to that described by Paillier (1999), to preserve the secrecy of the details of investors' limit orders while proving that the market is operating according to its published rules. (4) For each order, we encrypt the price and the quantity and place them in an open marketplace. (5) When two orders "meet", i.e., a buy and sell order have compatible price (buyer's bid $\geq$ seller's ask), the market notifies the traders and the orders are removed from the marketplace. (6)An appropriate clearinghouse completes the transaction.

Text C (1) Based on the experiences gained by a formerly developed monocular head camera a new wearable stereo head camera system will be developed. (2) Lightweight, yet high-resolution cameras will be moved using actuators with excellent dynamics and precision. (3) New kinematic solutions with a design close to the human oculomotor system are intended to reach bioanalogue characteristics. (4) By implementing elasticities into the motion control algorithms, camera movements similar to the eye movements of the biological model will be realized. (5) In this context, the use of actuators similar to human muscles will be investigated. (6) This requires adaptive motion control algorithms that optimize their adjustments for typical movements and states. (7) Size and weight considerations of a wearable system require an integrated mechanical and electronical design of actuator control, inverse kinematics, interfaces to the eyetracker and an inertial measurement unit. (8) The complete setup has to be integrated into an ergonomic head mount that is lightweight and comfortable to wear for the user and has a reasonable appearance. (9) Furthermore, a visual 3D environment will be generated from the image data of the camera, from actuator position data, and inertial information. (10) If this system is combined with the online 3D eyetracking system in a lightweight head mount then a gaze driven head-mounted stereo camera system can be used as a research tool for gaze control.

Text D (1) Collaborative action and shared intentionality is a specific ability of humans, and is regarded as the crucial difference to other species [8]. (1) An important factor for non-verbal communication are pointing gestures and facial expression. (2) The face not only communicates emotions, but also the direction of gaze, which is of particular importance for collaborative action. (3) Another persons gaze direction, determined by head orientation and eye angle within the head, indicates the locus of her visual attention. (4) Experimentally, it has been shown that gaze direction is analyzed rapidly and automatically and is able to shift the observers attention [6]. (5) Accordingly, motor intentions of an actor can be inferred by gaze monitoring [3]. (6) The second component of non-verbal communication, pointing gestures, can sometimes even override verbal descriptions [1], and may thus constitute a critical factor for collaborative action. (7) Finally, emotion expressed by facial expression [4] constitutes an important factor by giving feedback about the success of failure of collaborative action. (8) Collaborative action often involves learning from others by imitation. (9) A neural correlate is the mirrorneuron system [7]. (10) According to the direct matching hypothesis, observed actions are mapped onto motor representation of that action. (11) Recent evidence is provided by the fact that human eye movements are predictive, rather than reactive, when observing another person during a block stacking task [5]. (12) Regarding collaborative action in robotics, two basic trends are currently emerging: swarm robotics (e.g. [9]) centres about small mobile robots that (in a way similar to ant colonies) develop collective intelligence whereas human-centred service robotics (e.g. [10]) aims at enabling service robots of various different bodily structures to perform controlled joint action. (13) The latter is achieved by carrying on dialogues in natural language, interpreting/generating face expressions and gestures and by cooperating in physical contact. (14) The goal of the proposed project is to substantially advance the state-of-the-art in the second field. (15) One recent example for a joint-action setting involving more than just one robot is the Robonaut project which is carried out by the NASA [2]. (16) Here, two (real) robots are working in a simulated scenario in space with one human on structures, e.g. for the space station ISS. (17) Working together, the two Robonauts operated in various roles supporting the astronaut, who operates in both a leader and support role. (18) Note that the Robonauts are remote-controlled by humans, i.e. they do not afford any intelligence of their own.

5 How to Write a Scientific Paper

5.1 Writing papers is a skill

- Many papers are badly written
- Good writing is a skill you can learn
- Its a skill that is worth learning:
  - You will get more brownie points (more papers accepted etc)
  - Your ideas will have more impact
  - You will have better ideas

5.2 Writing papers: model 1

- Idea
- Do Research
- Write Paper

5.3 Writing papers: model 2

- Idea
- Write Paper
- Do Research
- Forces us to be clear, focused
- Crystallises what we don't understand
- Opens the way to dialogue with others: reality check, critique, and collaboration

5.4 Do not be intimidated

- Fallacy You need to have a fantastic idea before you can write a paper. (Everyone else seems to.)
- Write a paper, and give a talk, about any idea, no matter how weedy and insignificant it may seem to you
- Writing the paper is how you develop the idea in the first place
- It usually turns out to be more interesting and challenging that it seemed at first

5.5 Papers communicate ideas

- Your goal: to infect the mind of your reader with your idea, like a virus
- Papers are far more durable than programs (think Mozart)
- The greatest ideas are (literally) worthless if you keep them to yourself

5.6 Every paper tells a story

- what is the elevator pitch of your story?
- elevator pitch = summary that is short enough to give during an elevator ride
- the story is not what you did, but rather what you show, new ideas, new insights
- why interesting, important?
- why is the story of interest to others?
- universal truths, hot topic, surprises or unexpected results?
- know your story!
- Figure out what your idea is
- Idea - A re-usable insight,useful to the reader
- Make certain that the reader is in no doubt what the idea is. Be 100
  - The main idea of this paper is....
  - In this section we present the main contributions of the paper.
- Many papers contain good ideas, but do not distil what they are.
- Your paper should have just one ping: one clear, sharp idea
- Read your paper again: can you hear the ping?
- You may not know exactly what the ping is when you start writing; but you must know when you finish
- If you have lots of ideas, write lots of papers

5.7 The purpose of your paper is...

- not to describe the WizWoz system
- Your reader does not have a WizWoz
- She is primarily interested in re-usable brain-stuff, not executable artefacts

5.8 Write top down

- computer scientists (and most human beings) think this way!
- state broad themes/ideas first, then go into detail
- context, context, context
- even when going into detail write top down!

5.9 Introduction: crucial, formulaic

if reader not excited by intro, paper is lost recipe:

- para. 1: motivation: broadly, what is problem area, why important?
- para. 2: narrow down: what is problem you specifically consider
- para. 3: In the paper, we .: most crucial paragraph, tell your elevator pitch
- para. 4: how different/better/relates to
- para. 5: The remainder of this paper is structured as follows

5.10 Master the basics of organized writing

- paragraph = ordered set of topically-related sentences
- lead sentence sets context for paragraph
- might tie to previous paragraph
- sentences in paragraph should have logical narrative flow, relating to theme/topic
- don't mix tenses in descriptive text
- one sentence paragraph: warning!
- Here is a problem
- Its an interesting problem
- Its an unsolved problem
- Here is my idea
- My idea works (details, data)
- Heres how my idea compares to other peoples approaches

5.11 Structure of Conference Paper

- Title (1000 readers)
- Abstract (4 sentences, 100 readers)
- Introduction (1 page, 100 readers)
- The problem (1 page, 10 readers)
- My idea (2 pages, 10 readers)
- The details (5 pages, 3 readers)
- Related work (1-2 pages, 10 readers)
- Conclusions and further work (0.5 pages)

5.12 Put yourself in place of the reader

- less is more: I would have sent you less if I had had time
- take the time to write less
- readers shouldnt have to work
- wont dig to get story, understand context, results
- need textual signposts to know where story is going, context to know where they are good: e.g., Having seen that let us next develop a model for . Let Z be .
- bad: Let Z be
- what does reader know/not know, want/not want?
- write for reader, not for yourself
- page upon page of dense text is no fun to read
- avoid cramped feeling of tiny fonts, small margins
- create openness with white space: figures, lists
- enough context/information for reader to understand what you write?
- no one has as much background/content as you
- no one can read your mind
- all terms/notation defined?

5.13 No one (not even your mother) is as interested in this topic as you

- so you had better be (or appear) interested
- tell readers why they should be interested in your story
- don't overload reader with 40 graphs:
- think about main points you want to convey with graphs
- cant explore entire parameter space
- don't overload reader with pages of equations
- put long derivations/proofs in appendix, provide sketch in body of paper

5.14 State the results carefully

- clearly state assumptions (see overstate/understate your results) experiment/simulation description: enough info to nearly recreate experiment/description
- simulation/measurements:
- statistical properties of your results (e.g., confidence intervals)
- are results presented representative? or just a corner case that makes the point you want to make

5.15 Dont overstate/understate your results

- overstatement mistake:
  - We show that X is prevalent in the Internet
  - We show that X is better than Y when only actually shown for one/small/limited cases
- understatement mistake: fail to consider broader implications of your work
- if your result is small, interest will be small
- rock the world

5.16 Study the art of writing

- writing well gives you an unfair advantage
- writing well matters in getting your work published in top venues
- highly recommended:
  - The Elements of Style, W. Strunk, E.B. White, Macmillan Publishing, 1979
  - Writing for Computer Science: The Art of Effective Communication, Justin Sobel, Springer 1997.
- who do you think are the best writers in your area: study their style

5.17 Good writing takes times

- give yourself time to reflect, write, review, refine
- give others a chance to read/review and provide feedback
- get a readers point of view
- find a good writer/editor to critique your writing
- starting a paper three days before the deadline, while results are still being generated, is a non-starter