Distributed Real-Time Control Systems

Module 32

Writing Technical Reports

Sources

Some of the contents of this presentation inspired and/or extracted from:

***The Elements of Style (1918)*, William Strunk, E.B. White (online).**

***Final Year Handbook*, D. Vernon, Etilasat University College, rev 2.0, 2007.**

Documenting Technical Work

Summarise information for easy access: **concise**, **accurate** and **complete** as possible:

1. **For you**, to recall what you have done and do it faster next time.

2. **For others**, to understand what you have done.

Make sure others can understand your work:

So they can develop or maintain your system.

So you get credit for it (your final mark depends on it!).

The Technical Report

The **consolidation** of the work. Will persist in time, on contrary to the project work, that will vanish in our memories…

Shows your skills in **Assimilating**, **Synthesising** and **Critically Appraising** the materials relevant to the project.

Assess your work critically, with a view of **what could be improved**.

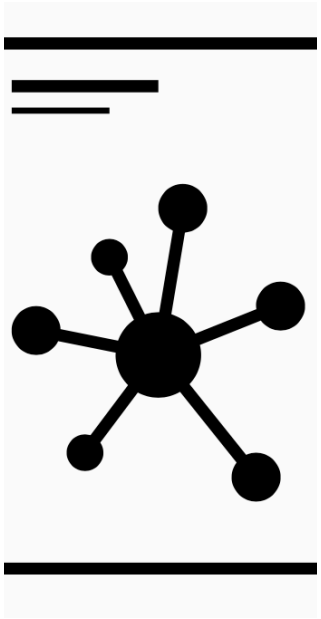
Write in your own words. Only this will show your synthesis and assimilation skills. **Otherwise things will not be clear and coherent**.

If you find a sentence from others that is so good that all world should know it, include it as a **direct quotation** and provide **reference** to the **original source**.

The Structure

- Abstract (a summary in less than 200 words)
- Introduction (motivation, challenges, main idea, objectives, outline)
- Problem Definition (Formulation of the problem and background)
- Related Work (state-of-the-art, how other address the problem)
- Proposed Approach (your approach, methodologies, innovations)
- Development (details on hardware/software implementation)
- Experiments (carefully explain the design of the experiments)
- Results (illustrate and comment on the results of experiments)
- Discussion (maybe in results)
- Conclusions & Future (critically comment on what was achieved and indicate points of improvement).
- Bibliography
- Appendices

General Guidelines



Motivate the reader: make the reader excited with your work.

Tell enough early to attract his attention, but **not too much** that will confuse him:

- Abstract says all in few words.
- Introduction says all in more words.
- Body says all with (relevant) details.
- Leave irrelevant/boring details for appendices.

Do **not** write in chronological order. This may make sense for you, but not for the reader.

Guide the reader to easily follow the story-line – **organize** your sections with a logical sequence, **link** sentences between sections/paragraphs, **remind** the reader of important messages, **give cues** for the things to come.

Do not expand your difficulties – **summarize** them.

Abstract

- A **highly summarized** description of the work.
- Often a **single paragraph** (approx 200 words), at most one page for large documents.
- Identify the **problem**, highlight the **difficulty**, emphasize the **contribution**, sketch the **approach**, underline the **achievements**.

A B S T R A C T

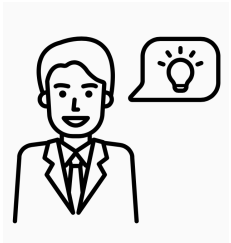
In this paper we propose a novel distributed algorithm to solve degenerate linear programs on asynchronous peer-to-peer networks with distributed information structures. We propose a distributed version of the well-known simplex algorithm for general degenerate linear programs. A network of agents, running our algorithm, will agree on a common optimal solution, even if the optimal solution is not unique, or will determine infeasibility or unboundedness of the problem. We establish how the multi-agent assignment problem can be efficiently solved by means of our distributed simplex algorithm. We provide simulations supporting the conjecture that the completion time scales linearly with the diameter of the communication graph.

Keywords

- **Keywords** are important to index documents and **facilitate search**.
- Identify the **aspects of interest** for other researchers – these are the keywords: the application, the formulations, the algorithms, the tools, etc…
- What are good keywords for this year's project?

Introduction

- **Motivate** the problem. Why is **worth working** on the problem ? What is the **impact** of solving the problem. Give **examples**.
- If applicable, add a historical perspective.
- What are the **Difficulties**? Why is it not solved yet ?
- What are the **current approaches** to solve the problem and their **limitations**?
- What is your approach to **do better**?
- What are the **objectives** of the work? What **methods** are going to be used ?
- Sketch the **outline** of the paper.
- Summarize your **contributions**.



Problem Definition

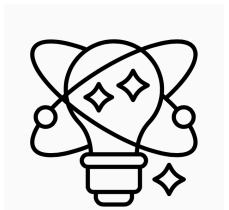
- Here you should define the problem in the less ambiguous possible way.
- Provide the mathematical **equations** and **notation** to be used in the rest of the report. Number the equations, in case you need to refer to them later.
- Introduce the **concepts**, **background** knowledge, well known **technologies**, and **frameworks** that you will need to use in your work.
- Do not be exhaustive. Provide **simple/short** descriptions, and provide **references** for who wants to know more.

SCDTR 19/20 Project Report Topics for Problem Definition

- Formulate the illumination control problem as Optimal Control.

Related Work / State-of-the-art
(more relevant in scientific researh papers)

- **Focus**: identify the most important aspect of your work. In which aspect do you want your work to be remembered.
- Identify works that have the **same spirit** of yours.
- Globally identify **positive points** of your work. Why is it better / more complete / more elegant that the others?



Proposed Approach

- Describe the **methodology**, i.e. the theoretical framework, to address the problem at hand.
- Identify any **assumptions** required for the operation of the system. What are the external facts (**preconditions** and pre-existing **requirements**) that must hold for the proposed method to work.
- Identify the core components of your methodology. Maybe include a conceptual diagram of these components and how they are related.
- Create **subsections** for each of core components of your approach.

SCDTR 19/20 Project Report Topics for Proposed Approach

- Topics for the Proposed Approach Section
  - Decentralized Control
  - Non cooperative control
    - local PID controllers
  - Cooperative control
    - The consensus algorithm

Development

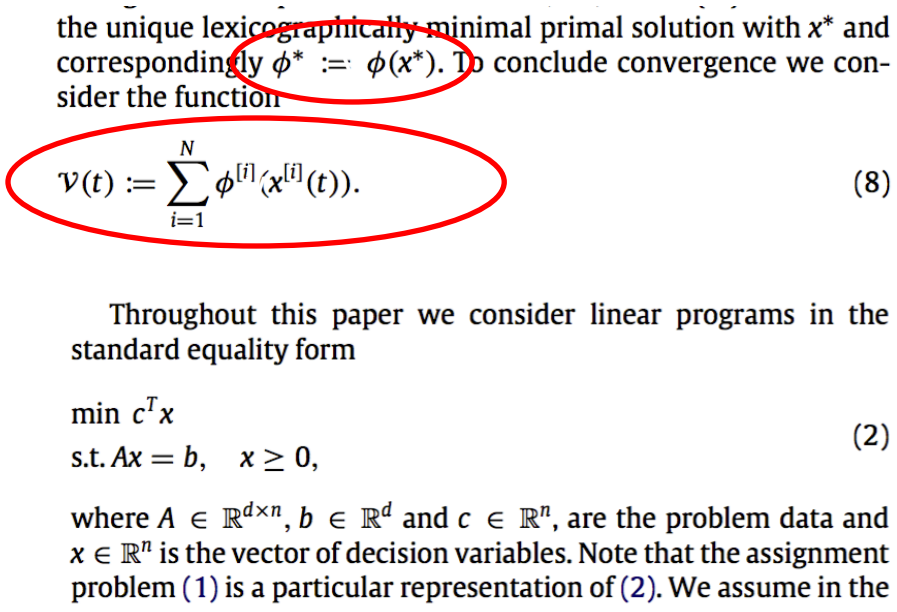
- This section should present **all** the **facts** that **allow replication** of the work by others.
- Start with a the **overall architecture** of the implementation. Maybe introduce a **diagram** to clearly show the main components and flows of information.
- Create **subsections** for each of the components and their integration. Software listings, circuit diagrams, mathematical proofs and schematics should go to **appendix** and referred in the main text.
- **Links** to software code can be provided (in fact are preferred over software listings)
- **Focus** on topics by their **importance** in the overall system, **not** by their **difficulty** or the **chronological** order you worked on them.

SCDTR 19/20 Project Report

- Topics for the Development Section
  - Overall System Diagram
  - The luminaire: construction and modeling,
  - The local controller
  - The distributed controller
  - Initialization and calibration
  - Communications
  - The PC Application

Equations

- Equation can be written **inline** or in separate lines.
- **Number** equations that you need to refer to later.
- **Always define all symbols** present in the equations, either before, or after.
- **Equations are part of text**, only in a different language. Use puctuation on equations as usual after equations.
- If an equation does not end a paragraph, do **not indent** the line after the equation.



the unique lexicographically minimal primal solution with x^* and correspondingly $\phi^* := \phi(x^*)$. To conclude convergence we consider the function

$$\mathcal{V}(t) := \sum_{i=1}^{N} \phi^{[i]}(x^{[i]}(t)). \tag{8}$$

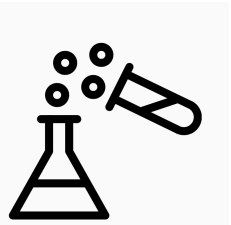
Throughout this paper we consider linear programs in the standard equality form

$$\begin{aligned} &\min\ c^T x \\ &\text{s.t. } Ax = b, \quad x \geq 0, \end{aligned} \tag{2}$$

where $A \in \mathbb{R}^{d \times n}$, $b \in \mathbb{R}^d$ and $c \in \mathbb{R}^n$, are the problem data and $x \in \mathbb{R}^n$ is the vector of decision variables. Note that the assignment problem (1) is a particular representation of (2). We assume in the

Experiments

- Experiments are done to **validate** the approach.
- Explain your experimental **setup** and **protocol**. Clearly describe the **conditions** and **methods** used in the experiments. Take pictures and diagrams of the setup.
- Provide some implementation details that you find relevant. If you what to show code of flowcharts, link to **appendices**.
- Algorithms have parameters. Explain which **parameters** you use and/or how you **tune** them.
- To access the influence of a condition in the experiments, variations on that condition are performed. Explain the **variations** introduced in the experiments.
- Define the evaluation **metrics**. Explain what measurements you take from the experiment and what metrics you use to quantitatively evaluate the methods.



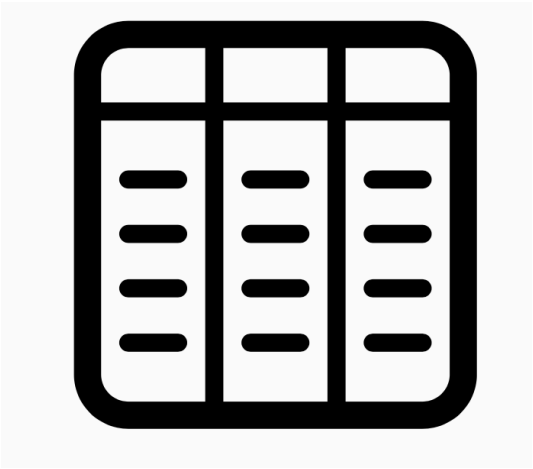
Results

- Present the results of the experiments in **figures** or **tables**.
- If possible, make **videos**, put them on youtube, and provide a **link** in the report.
- Videos should be **commented** or **subtitled**.
- **Organize** figures and tables such that you can check easily the important facts about the method: advantages vs disadvantages, **compare** between conditions, etc.
- **Refer** to the figures and tables in the main text of the document and briefly describe the main observation. Talk first about the most important aspects. Leave curiosities and less important facts to the end.
- Be **fair** on the **good** and **bad** points about the results, **but always be positive**. If your method is worse than expected, try to justify the reasons and provide suggestions for improvement.

SCDTR 19/20 Project Report

- Topics for Experiments/Results Section
  - Advantage of Combined Feedback/Feedforward control.
  - Advantage of Global vs Local Control
  - Plots of the controlled and manipulated variables.
  - Quantification of the solutions: plots/tables with comfort/flicker/energy metrics.

Figures and Tables



- **Always** put **units** and **labels** in the axes of figures and headers of tables.
- In figures with multiple plots, make sure to insert a **legend** identifying the different plots.
- All figures and tables should be **referred** in the main text. Do not leave them orphans.
- All figures and text must have a **succinct self contained description** (caption) such that a reader can understand it without reading the main text. **Describe all symbols** in the figure that are not obvious.
- The **caption** should be complete but only **descriptive**. Do **not make judgements** about results (good or bad) here; judgements should go to the main text.
- If your figure has many **subfigures**, make sure to identify in which **aspect they differ** (different parameters? different conditions ?).

Figures Examples

Good: self-contained

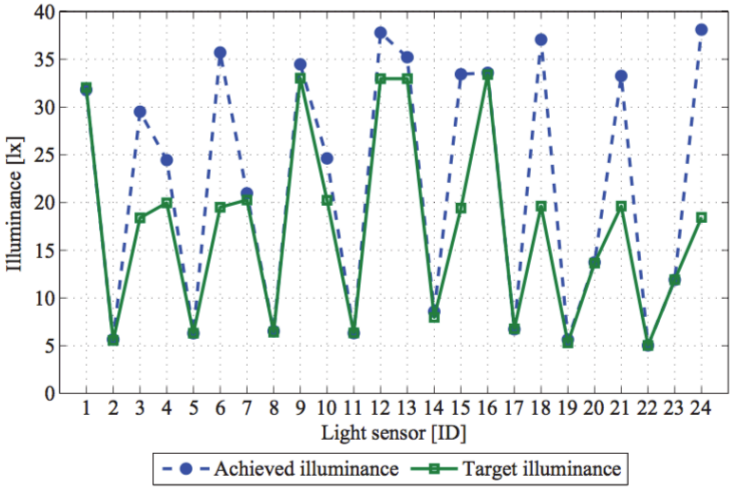


Fig. 10. Target versus achieved illuminance values at light sensors at 10:53 hours.

Not so good: what are L_o and L_u?

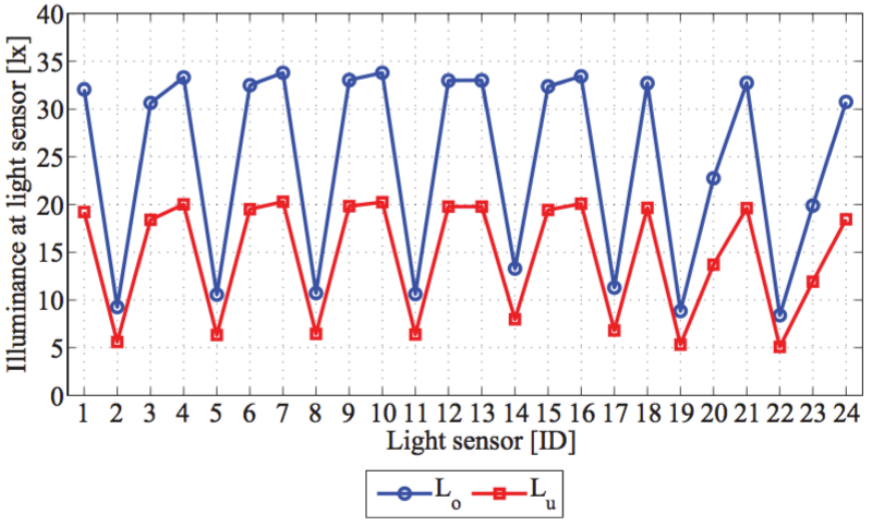


Fig. 6. Target illuminance values at light sensors.

Conclusions

- Conclusions **summarize** the main achievements of the work.
- Also identify other aspects that are **relevant** for other researchers.
- Stress the **contributions** and how the world will be a much better place to live after your work.
- Mention a few points worth looking at in **future work**, as a consequence of the conclusions.

Bibliographic References

- Bibliographic references are **links** to external documents that are mentioned in the main text.
- A complete list with all the links to the documents should be put in a section **after** the conclusions.
- There are several standard **styles** for bibliographic references, that define how different types of documents (Books, papers, reports) show up in the list, and how they are cited in the main text.

Bibliographic References

Plain

Items are cited: *The LaTeX Companion* book [1], the Einstein journal paper [2], and The LaTeX related items are [1, 3].

References

[1] M. Goossens, F. Mittelbach, and A. Samarin, *The LaTeX Companion*. Reading, Massachusetts: Addison-Wesley, 1993.

[2] A. Einstein, "Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]," *Annalen der Physik*, vol. 322, no. 10, pp. 891–921, 1905.

[3] D. Knuth, "Knuth: Computers and typesetting."

Bibliographic References

Apa-like

Items are cited: *The LaTeX Companion* book [Goossens et al., 1993], the Einstein journal paper [Einstein, 1905], and The LaTeX related items are [Goossens et al., 1993, Knuth,].

References

[Einstein, 1905] Einstein, A. (1905). **Z**ur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]. *Annalen der Physik*, 322(10):891–921.

[Goossens et al., 1993] Goossens, M., Mittelbach, F., and Samarin, A. (1993). *The LaTeX Companion*. Addison-Wesley, Reading, Massachusetts.

[Knuth,] Knuth, D. Knuth: Computers and typesetting.

Bibliographic References

Alpha

Items are cited: *The LaTeX Companion* book [GMS93], the Einstein journal paper [Ein05], and The LaTeX related items are [GMS93, Knu].

References

[Ein05] Albert Einstein. **Z**ur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]. *Annalen der Physik*, 322(10):891–921, 1905.

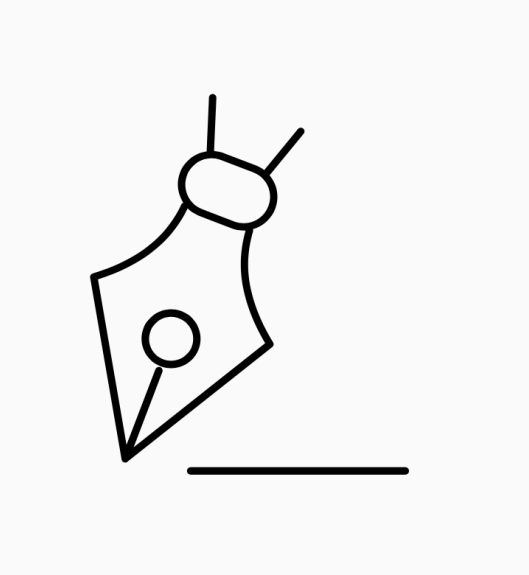
[GMS93] Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The LaTeX Companion*. Addison-Wesley, Reading, Massachusetts, 1993.

[Knu] Donald Knuth. Knuth: Computers and typesetting.

Tools

- Recommended Editing Tool: LaTeX
- Support for equations, figures, bibliographies.
- Check online platforms for collaborative editing:
  - Sharelatex
  - Overleaf
- For plots: Use matlab or excel, export as pdf.

Writing Style



- Use **short sentences**. Consider fractioning sentences bigger that 2-3 lines.
- Make sure sentences are **well formed**: at least a subject followed by a verb, and then an object.
- Logically **group** your text **in paragraphs**. A paragraph should be a self contained group sentences that, together, try to explain some fact, and that a reader can make sense without reading the other paragraphs.
- Try to **identify the meaning of each paragraph** in your document. Merge paragraphs that have the same meaning and fraction paragraphs whose sentences are not interdependent.
- For the most part, **eliminate adverbs and adjectives**, which can interfere with the **precise**, **clear**, and **straightforward** writing needed to communicate technical and scientific processes.
- Stay objective. **Eliminate opinions** and ("I think" or "I feel") from your writing so that the emphasis remains on the technical and scientific processes and facts.

More Writing Recommendations

- **Revise** your work many times.
- **Read other technical material**: scientific papers and magazines are good sources.
- **Omit needless words**. Unnecessary words distract the reader. Don't write, "This is a system the performance of which is very useful". Instead, write, "This is a useful system".
- **Write** in a way that comes **naturally**. Speak the sentence. If it sounds correct, trust your ear and use the sentence. If it sounds unnatural, rewrite it.
- **Avoid fancy words**; they don't impress anyone.
- **Be clear** in your expression. If the idea you are trying to convey is getting lost in a sea of words and phrases, draw a line through the sentence and start again.
- **Explain all acronyms** the first time you use them.