YANG HO AND JOHNNY NGUYEN, UNDER THE TUTELAGE OF DR. FRANC BRGLEZ, COMPUTER SCIENCE, NCSU

CSC499 HONORS CLASS PROJECT REPORT TEMPLATE

PUBLISHERS OF THIS REPORT

PUBLISHED BY PUBLISHERS OF THIS REPORT

TUFTE-LATEX.GOOGLECODE.COM

First printing, April 2015

Summary

THIS REPORT[1] summarizes our work on the project with a working title of *On Rapid Prototyping of Combinatorial Solvers*.

As a prerequisite, we have installed the *R* shell, the *tcl/TkCon* shell, the *python* shell, and various LaTeX templates. The default working shell is *bash* under linux for Yang Ho and *bash* under MacOSX for Johnny Nguyen. The files shared in the project are accessible on GitHub[2]. All of the initial prototypes of combinatorial solvers are written in tcl and are introduced, with required tcl commands and test cases, during the weekly class meeting by the instructor. There are several goals of this project. First, we observe the behaviour and learn about properties of each solver in real time by executing tcl commands and modifying the tcl code, rather than study the pseudo code in the abstract. Second, we learn about python to construct a solver that is comparable to the tcl implementation, not only in consiseness and clarity but most importanly, may well exceed the runtime performance of the tcl solver. Third, we instrument each solver for performance evaluation on a large number of instances running on the same CPU, so we can infer performance differences between solvers that are statistically significant.

Our current work involves two combinatorial solvers: one solves the *lightout puzzle*, one solves the *linear ordering problem*. The various phases of this project are summarized into sections as outlined under *Contents* below[3].

[1] The template for this report is based on an eBook template at `https://github.com/fbrglez/gitPublic/tree/master/xLatex` which itself is a derivate of the Tufte Book Template which can be accessed at `https://github.com/Tufte-LaTeX/tufte-latex`

[2] Franc Brglez. GitHub Archive on Rapid Prototyping of Combinatorial Solvers. For updates, see `https://github.com/fbrglez/gitPublic`, January 2015

[3] Note that each line in the "Contents" also represents a hyperlink to the respective section and subsection.

AND NOW, filler text with command `\lipsum[2]`. Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Contents

List of Figures

List of Tables

List of Algorithms

1
About Text Items

Text items in this chapter are divided into three sections:
(1) about notational conventions and schema of LaTeX files,
(2) text items selected from Tufte's book template,
(3) text items from other sources,
(4) typesetting examples of algorithms.

For details about how figures and tables are being represented, see Chapters 2 and 3. For additional examples of algorithms, see Chapter 4.

1.1 *About Notational Conventions and Schema for LaTeX files*

When collaborating with multiple authors using LaTeX, conventions about notation and file structures will save a lot of time. The schema in Figure 1.1 already illustrates a number of conventions that are being used in this document. The list below includes not only the items which are in plain sight in Figure 1.1, it also includes items we can observe in subdirectories *Algorithms*, *Figures*, and *Tables* as well as the *.tex files in these subdirectories.

.

- Consistently avoid file names with *underscore* (_).
- For complex algorithms, figures and tables, create a separate file which is prefixed with either `alg-`, `fg-` or `tb-` and move the file into the designated subdirectory. Use the rootname of the file for the label that is used to reference the algorithm, figure, or table. For example, we can thus refer to contents of file alg-global-search2-normal.tex as `Algorithm~\ref{alg-global-search2-normal}`. Notably, we embed contents of algorithm not only under `\algorithm`, `\algorithm-wide` environments but also under `\figure`, `\figure*` environments.
- There is always the easy-to-find-file `A00-main.tex`. This file not only invokes `\documentclass{tufte-book}` and the supporting files *tufte*, but also all items that are generic to the layout of the book and new command defitions that are content-specific with respect to the book. Finaly, this file also invokes the book chapters in a well-defined sequence such as Ch-About.tex, Ch-Figures.tex, Ch-Tables.tex, and Ch-Algorithms2.tex. The amount of text in a typical chapter will rarely extend beyond a single page since each chapter is likely to invoke a number of sections that reside in adjacent files and may represent contributions from several collaborating authors. For example, Ch-About.tex invokes four files in this order: Ch-About-Conventions.tex, Ch-About-Tufte.tex, Ch-About-Other.tex, Ch-About-Algorithms.tex.
- The only *.bib file in the directory ebook-test, bibTemp.bib, is initially an empty file. Within the file `A00-main.tex`, we use relative paths to define location of the 'nearby files' OPUS.bib and OPUS2.bib under xLatex: `\bibliography{\detokenize{../../OPUS}, \detokenize{../../OPUS2}, \detokenize{./bibTemp}}`. Both files, OPUS.bib and OPUS2.bib, are almost always up-to-date for use by all project participants, so the need for temporary bib items under the file bibTemp.bib seldom arises.

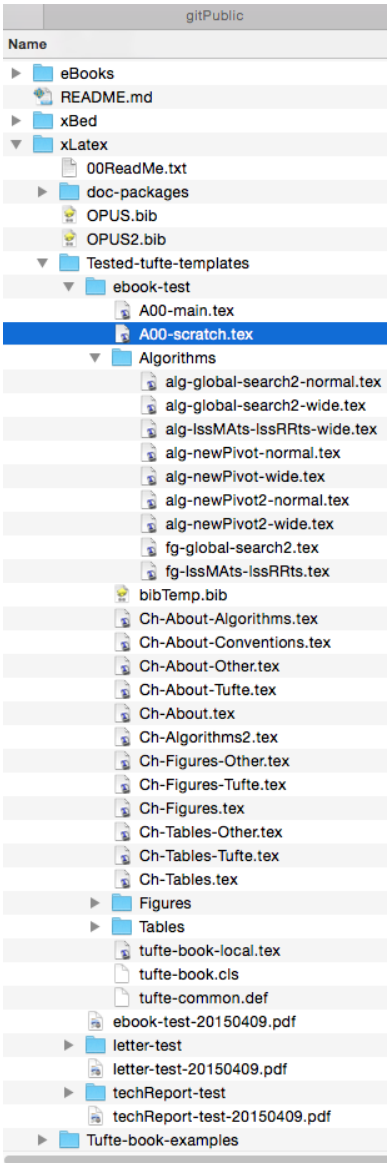


Figure 1.1: Notational conventions and schema for LaTeX files to support collaboration.

1.2 *Text Items Selected from Tufte's Book Template*

THE PRIMARY TEXT ITEMS for this section are selections from Tufte Book Template[1] Here, we extracted three sections from the Chapter on *On the Use of the tufte-book Document Class*: From this template, have extracted three sections

[1] The Tufte Book Template can be accessed at `https://github.com/Tufte-LaTeX/tufte-latex`.

- Page Layout: Headings
- Sidenotes
- References

However, in this document, we treat all of these three sections as subsections.

Page Layout: Headings

TUFTE'S BOOKS include the following heading levels: parts, chapters,[2] sections, subsections, and paragraphs. Not defined by default are: sub-subsections and subparagraphs.

[2] Parts and chapters are defined for the `tufte-book` class only.

Heading	Style	Size
Part	roman	24/36×40 pc
Chapter	italic	20/30×40 pc
Section	italic	12/16×26 pc
Subsection	italic	11/15×26 pc
Paragraph	italic	10/14

Table 1.1: Heading styles used in *Beautiful Evidence*.

Paragraph Paragraph headings (as shown here) are introduced by italicized text and separated from the main paragraph by a bit of space.

This style provides A- and B-heads (that is, `\section` and `\subsection`), demonstrated above.

If you need more than two levels of section headings, you'll have to define them yourself at the moment; there are no pre-defined styles for anything below a `\subsection`. As Bringhurst points out in *The Elements of Typographic Style*,[3] you should "use as many levels of headings as you need: no more, and no fewer."

[3] Robert Bringhurst. *The Elements of Typography*. Hartley & Marks, 3.1 edition, 2005

The Tufte-LaTeX classes will emit an error if you try to use `\subsubsection` and smaller headings.

IN HIS LATER BOOKS,[4] Tufte starts each section with a bit of vertical space, a non-indented paragraph, and sets the first few words of the

[4] Edward R. Tufte. *Beautiful Evidence*. Graphics Press, LLC, first edition, May 2006

sentence in SMALL CAPS. To accomplish this using this style, use the `\newthought` command:

```
\newthought{In his later books}, Tufte starts...
```

Sidenotes

One of the most prominent and distinctive features of this style is the extensive use of sidenotes. There is a wide margin to provide ample room for sidenotes and small figures. Any `\footnotes` will automatically be converted to sidenotes.[5] If you'd like to place ancillary information in the margin without the sidenote mark (the superscript number), you can use the `\marginnote` command.

[5] This is a sidenote that was entered using the `\footnote` command.

This is a margin note. Notice that there isn't a number preceding the note, and there is no number in the main text where this note was written.

The specification of the `\sidenote` command is:

`\sidenote[`⟨*number*⟩`][`⟨*offset*⟩`]{`*Sidenote text.*`}`

Both the ⟨*number*⟩ and ⟨*offset*⟩ arguments are optional. If you provide a ⟨*number*⟩ argument, then that number will be used as the sidenote number. It will change of the number of the current sidenote only and will not affect the numbering sequence of subsequent sidenotes.

Sometimes a sidenote may run over the top of other text or graphics in the margin space. If this happens, you can adjust the vertical position of the sidenote by providing a dimension in the ⟨*offset*⟩ argument. Some examples of valid dimensions are:

```
1.0in    2.54cm    254mm    6\baselineskip
```

If the dimension is positive it will push the sidenote down the page; if the dimension is negative, it will move the sidenote up the page.

While both the ⟨*number*⟩ and ⟨*offset*⟩ arguments are optional, they must be provided in order. To adjust the vertical position of the sidenote while leaving the sidenote number alone, use the following syntax:

`\sidenote[][`⟨*offset*⟩`]{`*Sidenote text.*`}`

The empty brackets tell the `\sidenote` command to use the default sidenote number.

If you *only* want to change the sidenote number, however, you may completely omit the ⟨*offset*⟩ argument:

`\sidenote[`⟨*number*⟩`]{`*Sidenote text.*`}`

The `\marginnote` command has a similar *offset* argument:

`\marginnote[`⟨*offset*⟩`]{`*Margin note text.*`}`

References

References are placed alongside their citations as sidenotes, as well. This can be accomplished using the normal `\cite` command.[6]

The complete list of references may also be printed automatically by using the `\bibliography` command. (See the end of this document for an example.) If you do not want to print a bibliography at the end of your document, use the `\nobibliography` command in its place.

To enter multiple citations at one location,[7] you can provide a list of keys separated by commas and the same optional vertical offset argument: `\cite{Tufte2006,Tufte1990}`.

`\cite[`⟨*offset*⟩`]{`*bibkey1*`,`*bibkey2*`,...}`

[6] The first paragraph of this document includes a citation.

[7] Edward R. Tufte. *Beautiful Evidence*. Graphics Press, LLC, first edition, May 2006; and Edward R. Tufte. *Envisioning Information*. Graphics Press, Cheshire, Connecticut, 1990

1.3 *About Text Items from Other Sources*

THE PRIMARY TEXT ITEMS for this section are selections from[8].

The command `\cmt` as listed below, [creates a 'comment' sentence like this one.]

```
\newcommand{\cmt}[1]{\textsf{[#1]}}
```

The command `\OMIT` as listed below

```
\newcommand{\OMIT}[1]{}
```

suppresses a block of text listed in the latex source code below (it makes it invisible).

Local paragraph. This boldface headings, terminated with a period, *Local paragraph.* has been created by using the local command `\TOPIC`: see the command below

```
\newcommand{\TOPIC}[1]{\vspace{1.3ex}\par\noindent\textbf{#1.}}
```

NOTE: such heading may be considered 'too bold' in the context of Tufte's ideas in *Beautiful Evidence*.

Tufte's Paragraph Paragraph headings (as shown here) are introduced by italicized text and separated from the main paragraph by a bit of space. The command is

```
\paragraph{}
```

About the labs problem. The *aperiodic low-autocorrelation binary sequence* (`labs`) problem has a simple formulation: take a binary sequence of length L, $S = s_1 s_2 \ldots s_L$, $s_i \in \{+1, -1\}$, the autocorrelation function $C_k(S) = \sum_{i=1}^{L-k} s_i s_{i+k}$, and minimize the energy function:

$$E(S) = \sum_{k=1}^{L-1} C_k^2(S) \tag{1.1}$$

or alternatively, maximize the *merit factor* F[9]:

$$F(S) = L^2/(2E(S)). \tag{1.2}$$

The asymptotic value for the maximum merit factor F, introduced by Golay, has been re-derived using arguments from statistical mechanics[10]:

$$\text{as} \quad L \to \infty, \quad \text{then} \quad F \to 12.3248 \tag{1.3}$$

The publication of the asymptotic value in Eq. 1.3 is providing an on-going challenge since no published solutions can yet claim to converge to this value as the length of the sequence increases.

Creating a filler text. The remainder of this paragraph has been created with the command `\lipsum[4]`. Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices.

[8] Borko Bošković, Franc Brglez, and Janez Brest. Low-Autocorrelation Binary Sequences: On Improved Merit Factors and Runtime Predictions to Achieve Them. `http://arxiv.org/`, *also under journal review*, 2015

[9] Marcel J.E. Golay. Sieves for low autocorrelation binary sequences. *IEEE: Transactions on Information Theory*, 23:43–51, 1977; Marcel J.E. Golay. The merit factor of long low autocorrelation binary sequences. *IEEE: Transactions on Information Theory*, 28:543–549, 1982; and Marcel J.E. Golay and Duncan B. Harris. A new search for skewsymmetric binary sequences with optimal merit factors. *Information Theory, IEEE Transactions on*, 36(5):1163–1166, 1990

[10] Jacob Bernasconi. Low autocorrelation binary sequences: statistical mechanics and configuration space analysis. *J. Phys.*, 48:559–567, April 1987

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

More about the labs problem. Finding the optimum sequence is significantly harder than solving the special cases of the Ising spin-glass problems with limited interaction and periodic boundary conditions, for example[11]. While effective methods have been presented to solve the special cases[12], up to $L = 400$, the best merit factors that has also been *proven optimal* for the problem as formulated in Eq. 1.2 are presently known for values of $L \leq 60$ only[13]. A web page of `labs` best merit factors and solutions, up to the sequence length of $L = 304$, has been compiled by Joshua Knauer in 2002. This page is no longer accessible and has now been restored at two mirroring sites[14] next to additional and comprehensive tables of *best-value solutions*. These tables contain not only updates on the best known figures of merit but also on the number of *unique* solutions in *canonic form* and the solutions themselves.

Now, we need more text on this page if we are to make extra space for the citation that should be moved into the margins on the next page. Can or should we have *some citations* not appear in the margin, only at under Bibliography at the very end? Such a feature would not appear logical in the context of Tufte's book template, would it? The message from Tufte's book template seem to be: do not overcrowd with citations on any given page, have sufficient text to justify the introduction (and context) of any new citation ... This criterion can be considered different for books when compared to peer-reviewed article ...

This text has been created with the command `\lipsum[4]`. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis,

[11] Martin Pelikan and David E. Goldberg. Hierarchical boa solves ising spin glasses and maxsat. In *Proceedings of the 2003 international conference on Genetic and evolutionary computation: PartII*, GECCO'03, pages 1271–1282, Berlin, Heidelberg, 2003. Springer-Verlag

[12] Martin Pelikan and David E. Goldberg. Hierarchical boa solves ising spin glasses and maxsat. In *Proceedings of the 2003 international conference on Genetic and evolutionary computation: PartII*, GECCO'03, pages 1271–1282, Berlin, Heidelberg, 2003. Springer-Verlag

[13] Stephan Mertens. Exhaustive search for low-autocorrelation binary sequences. *Journal of Physics A: Mathematical and General*, 29:473–481, 1996. The sequences for 48 < L <= 60 have been found with an improved implementation due to Heiko Bauke. All values are available at `http://www-e.uni-magdeburg.de/mertens/research/labs/open.dat`

[14] LABS Problem: 2002 Merit Factor Records posted by Knauer. Now reposted under two mirrroring sites: `http://cbl.ncsu.edu/xBed/xProj/B.labs/` and `http://labraj.uni-mb.si/en/B.labs`, 2014

diam. Duis eget orci sit amet orci dignissim rutrum.

Relationships between results reported in[15] and[16], and all subsequent updates under[17] are depicted in four panels in Figure 2.4 (See Chapter 2. The latest experimental results support the trend towards the conjectured asymptotic value of $F = 12.3248$, however as we demonstrate later on in the paper, the computational cost to reach this value may well exceed the currently available resources unless a better solver is discovered.

[15] Marcel J.E. Golay. The merit factor of long low autocorrelation binary sequences. *IEEE: Transactions on Information Theory*, 28:543–549, 1982; and G.F.M. Beenker, T.A.C.M. Claasen, and P.W.C. Hermens. Binary sequences with a maximally flat amplitude spectrum. *Philips J. Res.*, vol. 40:289–304, 1985

[16] Jacob Bernasconi. Low autocorrelation binary sequences: statistical mechanics and configuration space analysis. *J. Phys.*, 48:559–567, April 1987; and Marcel J.E. Golay and Duncan B. Harris. A new search for skewsymmetric binary sequences with optimal merit factors. *Information Theory, IEEE Transactions on*, 36(5):1163–1166, 1990

[17] Franc Brglez, Janez Brest, and Borko Bošković. Home Page of the LABS Problem Performance Experiments and Solutions. Posted under two mirrroring sites: `http://cbl.ncsu.edu/xBed/xProj/B.labs/` and `http://labraj.uni-mb.si/en/B.labs`, 2014

1.4 *Typesetting Examples of Algorithms*

THERE ARE A NUMBER of examples of algorithms in this section. For additional examples of algorithms, see Chapter 4.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Algorithm 1 Procedure newPivot.saw – normal width.

1: **procedure** `newPivot.saw`($\underline{\varsigma}_{\omega_s-1}, Walk_{\omega_s-1}$)
2: $\mathbb{Z} \leftarrow i = 1, 2, \ldots, L$
3: $\mathbb{Z}_p \leftarrow permute(\mathbb{Z})$
4: $\mathcal{N}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\underline{\varsigma}^i_{\omega_s-1} | d(\underline{\varsigma}_{\omega_s-1}, \underline{\varsigma}^i_{\omega_s-1}) = 1, i \in \mathbb{Z}_p\}$
5: $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\mathcal{N}(\underline{\varsigma}_{\omega-1}) | \underline{\varsigma}^i_{\omega_s-1} \notin Walk_{\omega_s-1}\}$
6: **if** $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \neq \emptyset$ **then**
7: $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `bestNeighbor`$(\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}))$
8: $Walk_{\omega_s} \leftarrow Walk_{\omega_s-1} \cup \{\underline{\varsigma}_{\omega_s}\}$
9: $\tau \leftarrow \tau + |\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1})|$ ▷ update *cntProbe*
10: **else** ▷ **deal with a trapped pivot**
11: $\beta = \beta + 1$
12: $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `coordInit`() ▷ re-initialize
13: $Walk_{\omega_s} \leftarrow \{\underline{\varsigma}_{\omega_s}\}$
14: $\tau \leftarrow \tau + 1$ ▷ update *cntProbe*
15: **end if**
16: **return** $Walk_{\omega_s} : \underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s})$
17: **end procedure**

THE ALGORITHM EXAMPLES are listed in this order:

1. Algorithm 1 is in-line and normal width.
2. Algorithm 2 is in-line and full-width below a full-width Figure 2.3.
3. Algorithm 3 is on a full page and normal width.
4. Algorithm 3 is on a full page and full-width.
5. Algorithm 5 is at the top of the page and full-width.

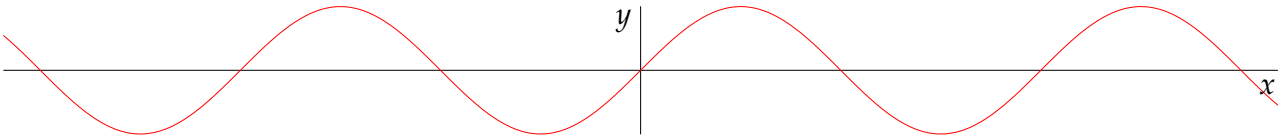


Figure 1.2: This graph shows $y = \sin x$ from about $x = [-10, 10]$. *Notice that this figure takes up the full page width.*

Algorithm 2 Procedure newPivot.saw – using algorithm-wide environment.

1: **procedure** `newPivot.saw`($\underline{\varsigma}_{\omega_s-1}, Walk_{\omega_s-1}$)
2: $\mathbb{Z} \leftarrow i = 1, 2, \ldots, L$
3: $\mathbb{Z}_p \leftarrow permute(\mathbb{Z})$
4: $\mathcal{N}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\underline{\varsigma}^i_{\omega_s-1} | d(\underline{\varsigma}_{\omega_s-1}, \underline{\varsigma}^i_{\omega_s-1}) = 1, i \in \mathbb{Z}_p\}$
5: $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\mathcal{N}(\underline{\varsigma}_{\omega-1}) | \underline{\varsigma}^i_{\omega_s-1} \notin Walk_{\omega_s-1}\}$
6: **if** $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \neq \emptyset$ **then**
7: $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `bestNeighbor`$(\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}))$
8: $Walk_{\omega_s} \leftarrow Walk_{\omega_s-1} \cup \{\underline{\varsigma}_{\omega_s}\}$
9: $\tau \leftarrow \tau + |\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1})|$ ▷ update *cntProbe*
10: **else** ▷ **deal with a trapped pivot**
11: $\beta = \beta + 1$
12: $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `coordInit`() ▷ re-initialize
13: $Walk_{\omega_s} \leftarrow \{\underline{\varsigma}_{\omega_s}\}$
14: $\tau \leftarrow \tau + 1$ ▷ update *cntProbe*
15: **end if**
16: **return** $Walk_{\omega_s} : \underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s})$
17: **end procedure**

Notably, typesetting of the Algorithm 2 results in excessive width, for better rendition of identical algorithm, see Algorithm 1 in the preceding page.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

On the next page, Algorithm 3 takes a full page at normal width. However, the version in Algorithm 4 describes the same algorithm, also on a full page, but in a wider, easier-to-read format.

Algorithm 3 A fully instrumented version of solver `lss0rel` – normal width.

procedure `lss0rel`($\sigma_0, \Theta_L^{ub}, t_{lmt}, \omega_{lmt}$)
  $\underline{\varsigma}_0 : \Theta(\underline{\varsigma}_0) \leftarrow$ `coordInit`(σ_0) ▷ initial solution
  $\tau \leftarrow 1$ ▷ initialize cntProbe
  $\underline{\varsigma}^* : \Theta(\underline{\varsigma}^*) \leftarrow \underline{\varsigma}_0 : \Theta(\underline{\varsigma}_0)$ ▷ initial best solution
  $isCens \leftarrow 0$ ▷ initialize *isCensored*
  $tgReached \leftarrow 0$ ▷ initialize *targetReached*
  $\beta \leftarrow 0$ ▷ initialize *cntTrapped*
  $\omega \leftarrow 0$ ▷ initialize total number of steps
  while true do
    $\omega_s : \underline{\varsigma}^* : \Theta(\underline{\varsigma}^*) \leftarrow$ `walk.saw`($\underline{\varsigma}_0 : \Theta(\underline{\varsigma}_0), t_{lmt}, \omega_{lmt}$) ▷ return a completed walk segment
    $\omega \leftarrow \omega + \omega_s$ ▷ update total number of steps
    if $\Theta(\underline{\varsigma}^*) \leq \Theta_L^{ub}$ **then**
      if $\Theta(\underline{\varsigma}^*) = \Theta_L^{ub}$ **then**
        $tgReached = 1$ ▷ upper-bound is reached
      else
        $tgReached = 2$ ▷ upper-bound is improved
      end if
      break
    end if
    if $t \geq t_{lmt}$ **then**
      $isCens \leftarrow 1$ ▷ return solution as "censored"
      break
    end if
    $\underline{\varsigma}_0 : \Theta(\underline{\varsigma}_0) \leftarrow$ `coordInit`() ▷ initialize a new walk segment
    $\tau \leftarrow \tau + 1$ ▷ update *cntProbe*
    $\omega \leftarrow \omega + 1$ ▷ update total number of steps
  end while
  $Table \leftarrow (\sigma_0, \underline{\varsigma}^*, \Theta(\underline{\varsigma}^*), \omega, \tau, t, isCens, tgReached)$
end procedure

procedure `walk.saw`($\underline{\varsigma}_0 : \Theta(\underline{\varsigma}_0), t_{lmt}, \omega_{lmt}$)
  if $\Theta(\underline{\varsigma}_0) \leq \Theta(\underline{\varsigma}^*)$ **then**
    $\underline{\varsigma}^* : \Theta(\underline{\varsigma}^*) \leftarrow \underline{\varsigma}_0 : \Theta(\underline{\varsigma}_0)$ ▷ new best solution
  end if
  $\omega_s \leftarrow 0$ ▷ walk segment length
  $Walk_0 \leftarrow \{\underline{\varsigma}_0\}$ ▷ new walk segment
  while $\Theta(\underline{\varsigma}^*) > \Theta_L^{ub}$ **and** $\omega_s < \omega_{lmt}$ **do**
    if $t \geq t_{lmt}$ **then** ▷ timeout
      break
    end if
    $\omega_s = \omega_s + 1$ ▷ **a new step!**
    $Walk_{\omega_s} : \underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$
      $\leftarrow$ `newPivot.saw`($\underline{\varsigma}_{\omega_s - 1}, Walk_{\omega_s - 1}$)
    if $\Theta(\underline{\varsigma}_{\omega_s}) \leq \Theta(\underline{\varsigma}^*)$ **then**
      $\underline{\varsigma}^* : \Theta(\underline{\varsigma}^*) \leftarrow \underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s})$
    end if
  end while
  return $\omega_s : \underline{\varsigma}^* : \Theta(\underline{\varsigma}^*)$
end procedure

procedure `newPivot.saw`($\underline{\varsigma}_{\omega_s - 1}, Walk_{\omega_s - 1}$)
  $\mathbb{Z} \leftarrow i = 1, 2, \ldots, L$
  $\mathbb{Z}_p \leftarrow permute(\mathbb{Z})$
  $\mathcal{N}(\underline{\varsigma}_{\omega_s - 1}) \leftarrow \{\underline{\varsigma}^i_{\omega_s - 1} | d(\underline{\varsigma}_{\omega_s - 1}, \underline{\varsigma}^i_{\omega_s - 1}) = 1, i \in \mathbb{Z}_p\}$
  $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s - 1}) \leftarrow \{\mathcal{N}(\underline{\varsigma}_{\omega - 1}) | \underline{\varsigma}^i_{\omega_s - 1} \notin Walk_{\omega_s - 1}\}$
  if $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s - 1}) \neq \emptyset$ **then**
    $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `bestNeighbor`($\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s - 1})$)
    $Walk_{\omega_s} \leftarrow Walk_{\omega_s - 1} \cup \{\underline{\varsigma}_{\omega_s}\}$
    $\tau \leftarrow \tau + |\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s - 1})|$ ▷ update *cntProbe*
  else ▷ **deal with a trapped pivot**
    $\beta = \beta + 1$
    $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `coordInit`() ▷ re-initialize
    $Walk_{\omega_s} \leftarrow \{\underline{\varsigma}_{\omega_s}\}$
    $\tau \leftarrow \tau + 1$ ▷ update *cntProbe*
  end if
  return $Walk_{\omega_s} : \underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s})$
end procedure

Algorithm 4 A fully instrumented version of solver `lss0rel` – using algorithm-wide environment.

procedure `lss0rel`($\sigma_0, \Theta_L^{ub}, t_{lmt}, \omega_{lmt}$)
  $\underline{\varsigma}_0{:}\Theta(\underline{\varsigma}_0) \leftarrow$ `coordInit`(σ_0) ▷ initial solution
  $\tau \leftarrow 1$ ▷ initialize cntProbe
  $\underline{\varsigma}^*{:}\Theta(\underline{\varsigma}^*) \leftarrow \underline{\varsigma}_0{:}\Theta(\underline{\varsigma}_0)$ ▷ initial best solution
  $isCens \leftarrow 0$ ▷ initialize *isCensored*
  $tgReached \leftarrow 0$ ▷ initialize *targetReached*
  $\beta \leftarrow 0$ ▷ initialize *cntTrapped*
  $\omega \leftarrow 0$ ▷ initialize total number of steps
  while true do
    $\omega_s{:}\underline{\varsigma}^*{:}\Theta(\underline{\varsigma}^*) \leftarrow$ `walk.saw`($\underline{\varsigma}_0{:}\Theta(\underline{\varsigma}_0), t_{lmt}, \omega_{lmt}$) ▷ return a completed walk segment
    $\omega \leftarrow \omega + \omega_s$ ▷ update total number of steps
    if $\Theta(\underline{\varsigma}^*) \leq \Theta_L^{ub}$ **then**
      if $\Theta(\underline{\varsigma}^*) = \Theta_L^{ub}$ **then**
        $tgReached = 1$ ▷ upper-bound is reached
      else
        $tgReached = 2$ ▷ upper-bound is improved
      end if
      break
    end if
    if $t \geq t_{lmt}$ **then**
      $isCens \leftarrow 1$ ▷ return solution as "censored"
      break
    end if
    $\underline{\varsigma}_0{:}\Theta(\underline{\varsigma}_0) \leftarrow$ `coordInit`() ▷ initialize a new walk segment
    $\tau \leftarrow \tau + 1$ ▷ update *cntProbe*
    $\omega \leftarrow \omega + 1$ ▷ update total number of steps
  end while
  $Table \leftarrow (\sigma_0, \underline{\varsigma}^*, \Theta(\underline{\varsigma}^*), \omega, \tau, t, isCens, tgReached)$
end procedure

procedure `walk.saw`($\underline{\varsigma}_0{:}\Theta(\underline{\varsigma}_0), t_{lmt}, \omega_{lmt}$)
  if $\Theta(\underline{\varsigma}_0) \leq \Theta(\underline{\varsigma}^*)$ **then**
    $\underline{\varsigma}^*{:}\Theta(\underline{\varsigma}^*) \leftarrow \underline{\varsigma}_0{:}\Theta(\underline{\varsigma}_0)$ ▷ new best solution
  end if
  $\omega_s \leftarrow 0$ ▷ walk segment length
  $Walk_0 \leftarrow \{\underline{\varsigma}_0\}$ ▷ new walk segment
  while $\Theta(\underline{\varsigma}^*) > \Theta_L^{ub}$ **and** $\omega_s < \omega_{lmt}$ **do**
    if $t \geq t_{lmt}$ **then** ▷ timeout
      break
    end if
    $\omega_s = \omega_s + 1$ ▷ **a new step!**
    $Walk_{\omega_s}{:}\underline{\varsigma}_{\omega_s}{:}\Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$
      $\leftarrow$ `newPivot.saw`($\underline{\varsigma}_{\omega_s-1}, Walk_{\omega_s-1}$)
    if $\Theta(\underline{\varsigma}_{\omega_s}) \leq \Theta(\underline{\varsigma}^*)$ **then**
      $\underline{\varsigma}^*{:}\Theta(\underline{\varsigma}^*) \leftarrow \underline{\varsigma}_{\omega_s}{:}\Theta(\underline{\varsigma}_{\omega_s})$
    end if
  end while
  return $\omega_s{:}\underline{\varsigma}^*{:}\Theta(\underline{\varsigma}^*)$
end procedure

procedure `newPivot.saw`($\underline{\varsigma}_{\omega_s-1}, Walk_{\omega_s-1}$)
  $\mathbb{Z} \leftarrow i = 1, 2, \ldots, L$
  $\mathbb{Z}_p \leftarrow permute(\mathbb{Z})$
  $\mathcal{N}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\underline{\varsigma}^i_{\omega_s-1} | d(\underline{\varsigma}_{\omega_s-1}, \underline{\varsigma}^i_{\omega_s-1}) = 1, i \in \mathbb{Z}_p\}$
  $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\mathcal{N}(\underline{\varsigma}_{\omega-1}) | \underline{\varsigma}^i_{\omega_s-1} \notin Walk_{\omega_s-1}\}$
  if $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \neq \emptyset$ **then**
    $\underline{\varsigma}_{\omega_s}{:}\Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `bestNeighbor`($\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1})$)
    $Walk_{\omega_s} \leftarrow Walk_{\omega_s-1} \cup \{\underline{\varsigma}_{\omega_s}\}$
    $\tau \leftarrow \tau + |\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1})|$ ▷ update *cntProbe*
  else ▷ **deal with a trapped pivot**
    $\beta = \beta + 1$
    $\underline{\varsigma}_{\omega_s}{:}\Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `coordInit`() ▷ re-initialize
    $Walk_{\omega_s} \leftarrow \{\underline{\varsigma}_{\omega_s}\}$
    $\tau \leftarrow \tau + 1$ ▷ update *cntProbe*
  end if
  return $Walk_{\omega_s}{:}\underline{\varsigma}_{\omega_s}{:}\Theta(\underline{\varsigma}_{\omega_s})$
end procedure

Algorithm 5 `lssMAts` and `lssRRts` algorithms – using algorithm-wide environment.

```
1: procedure lssMAts(Θ_L^ub, t_lmt)
2:     for i ← 1 to popsize do
3:         pop_i ← RandomBinarySequence(L)
4:         Evaluate(pop_i)
5:     end for
6:     Θ(ς*)← ValueBest(pop)
7:     while t < t_lmt and Θ(ς*) > Θ_L^ub do
8:         for i = 1 to offsize do
9:             if recombination is performed (p_X) then
10:                parent_1 ←Select(pop)
11:                parent_2 ←Select(pop)
12:                offspring_i ←Recombine(parent_1, parent_2)
13:            else
14:                offspring_i ←Select(pop)
15:            end if
16:            if mutation is performed (p_m) then
17:                offspring_i ←Mutate(offspring_i)
18:            end if
19:            offspring_i ←TabuSearch(offspring_i)
20:            Evaluate(offspring_i)
21:        end for
22:        pop ←Replace(pop, offspring)
23:        Θ(ς*)← ValueBest(pop)
24:    end while
25: end procedure
```

setting	value
population size:	100
mutation probability:	$2/(L+1)$
crossover probability:	0.9
tournament selection size:	2
crossover:	uniform
tabu search walk length:	a random choice from the range $[\frac{L}{2}, \frac{3L}{2}]$

```
1: procedure lssRRts(Θ_L^ub, t_lmt)
2:     pop_1 ← RandomBinarySequence(L)
3:     Evaluate(pop_1)
4:     Θ(ς*)← ValueBest(pop)
5:     while t < t_lmt and Θ(ς*) > Θ_L^ub do
6:         pop_1 ←RandomBinarySequence(L)
7:         pop_1 ←TabuSearch(pop_1)
8:         Evaluate(pop_1)
9:         Θ(ς*)← ValueBest(pop)
10:    end while
11: end procedure
```

On this page, Algorithm 5 is placed at the top of the page with the [!t] option. Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mol-

lis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

HERE IS a simple in-line Algorithm description we can include, with some restrictions, in a margin note as well.

Algorithm 6 Pseudo code for `lssRRts` – in-line version

1: **procedure** `lssRRts`(Θ_L^{ub}, t_{lmt})
2: $pop_1 \leftarrow$ `RandomBinarySequence`(L)
3: `Evaluate`(pop_1)
4: $\Theta(\underline{\varsigma}^*) \leftarrow$ `ValueBest(pop)`
5: **while** $t < t_{lmt}$ **and** $\Theta(\underline{\varsigma}^*) > \Theta_L^{ub}$ **do**
6: $pop_1 \leftarrow$`RandomBinarySequence`(L)
7: $pop_1 \leftarrow$`TabuSearch`(pop_1)
8: `Evaluate`(pop_1)
9: $\Theta(\underline{\varsigma}^*) \leftarrow$ `ValueBest(pop)`
10: **end while**
11: **end procedure**

.

HERE IS A MARGIN NOTE for a pseudo-code that describes a simple procedure. NOTE: we cannot use the `\algorithm` and `\caption` environment under `\marginnote`.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

1: **procedure** `lssRRts`(Θ_L^{ub}, t_{lmt})
2: $pop_1 \leftarrow$ `RandBinSeq`(L)
3: `Evaluate`(pop_1)
4: $\Theta(\underline{\varsigma}^*) \leftarrow$ `ValueBest(pop)`
5: **while** $t < t_{lmt}$ **and** $\Theta(\underline{\varsigma}^*) > \Theta_L^{ub}$ **do**
6: $pop_1 \leftarrow$`RandBinSeq`(L)
7: $pop_1 \leftarrow$`TabuSearch`(pop_1)
8: `Evaluate`(pop_1)
9: $\Theta(\underline{\varsigma}^*) \leftarrow$ `ValueBest(pop)`
10: **end while**
11: **end procedure**

2
About Figures

FIGURES IN THIS CHAPTER are divided into two sections: (1) figures from Tufte, (2) figures from other sources.

FOR DETAILS about how various text items are being represented, see Chapter 1.

2.1 *Figures from Tufte*

ABOUT THE FIGURES from Tufte:

- a margin figure, `fg-tufte-margin-helix`, Figure 2.1,
- a normal-width figure, `fg-tufte-normal-hilbertcurves`, Figure 2.2, and
- a full-width figure, `fg-tufte-wide-sine`, Figure 2.3.

.

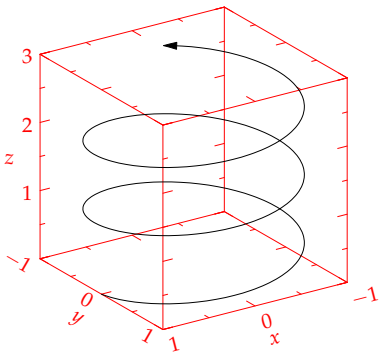


Figure 2.1: This is a margin figure. The helix is defined by $x = \cos(2\pi z)$, $y = \sin(2\pi z)$, and $z = [0, 2.7]$. The figure was drawn using Asymptote (`http://asymptote.sf.net/`).

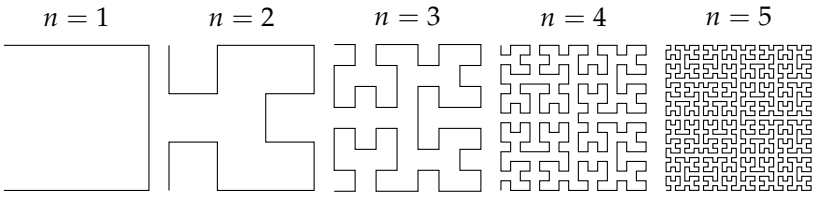


Figure 2.2: Hilbert curves of various degrees n. *Notice that this figure only takes up the main textblock width.*

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante.

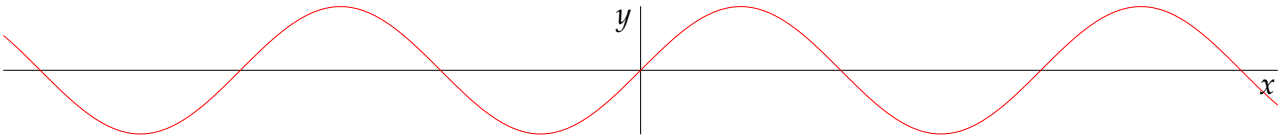


Figure 2.3: This graph shows $y = \sin x$ from about $x = [-10, 10]$. *Notice that this figure takes up the full page width.*

Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

2.2 *Figures from Other Sources*

THE FILE `fg-R-labs-wide-4-figures.tex` renders Figure 2.4, used in[1]. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

[1] Borko Bošković, Franc Brglez, and Janez Brest. Low-Autocorrelation Binary Sequences: On Improved Merit Factors and Runtime Predictions to Achieve Them. `http://arxiv.org/`, *also under journal review*, 2015

THE FILE `fg-R-labs-wide-6-figures.tex` renders Figure 2.5. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

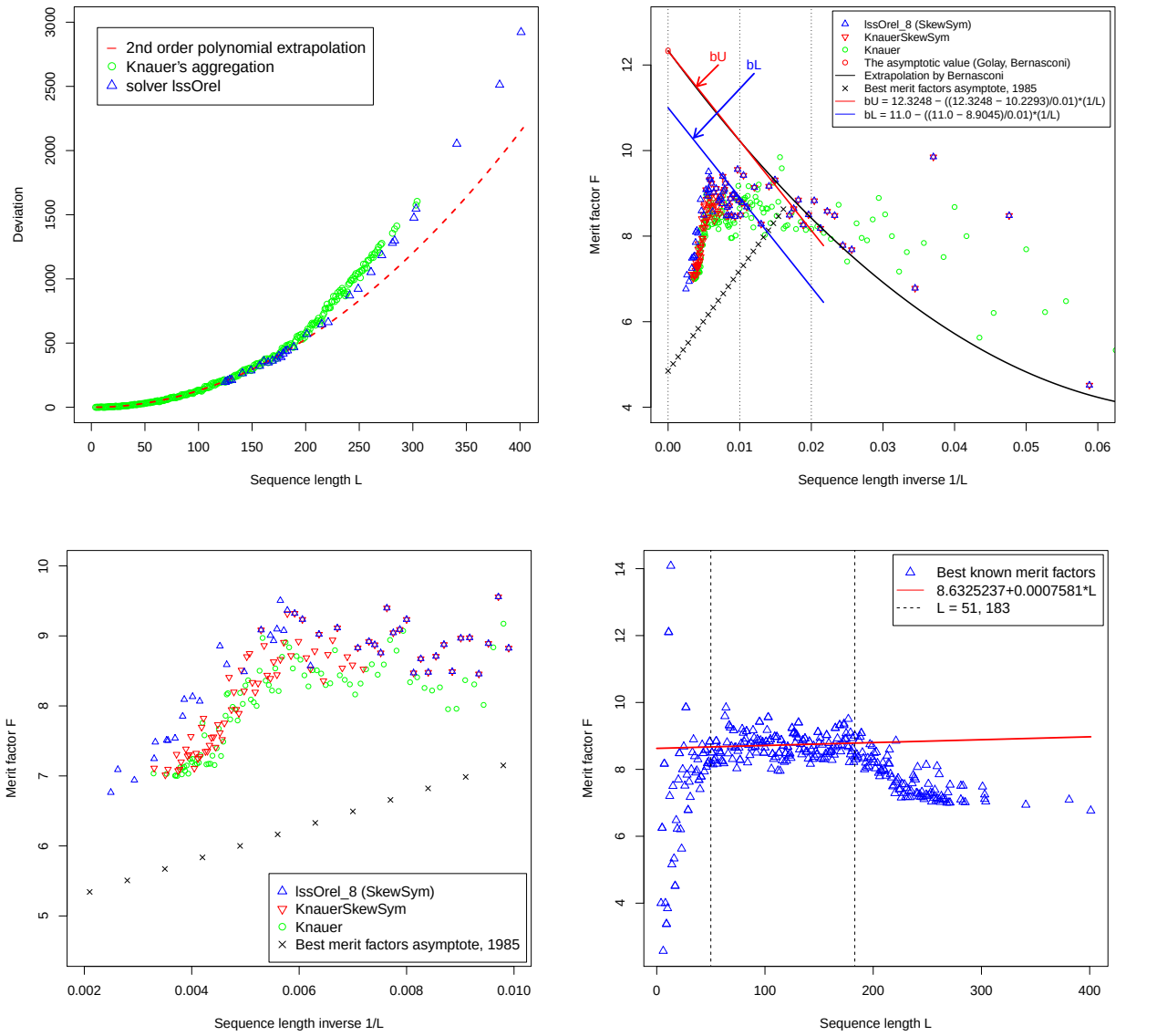


Figure 2.4: From the file fg-R-labs-wide-4-figures.tex *borrowed from* `Lib-OPUS2-labs-2015-arxiv-Boskovic`. **NOTE: both 'verb' and 'cite' commands seem disabled under 'figure environment'!** (a) it may not be possible to create (a) in this file with LaTeX... may need to create it in R; (b) it may not be possible to create (b) in this file with LaTeX... may need to create it in R; (c) it may not be possible to create (c) in this file with LaTeX... may need to create it in R; (d) it may not be possible to create (d) in this file with LaTeX... may need to create it in R.

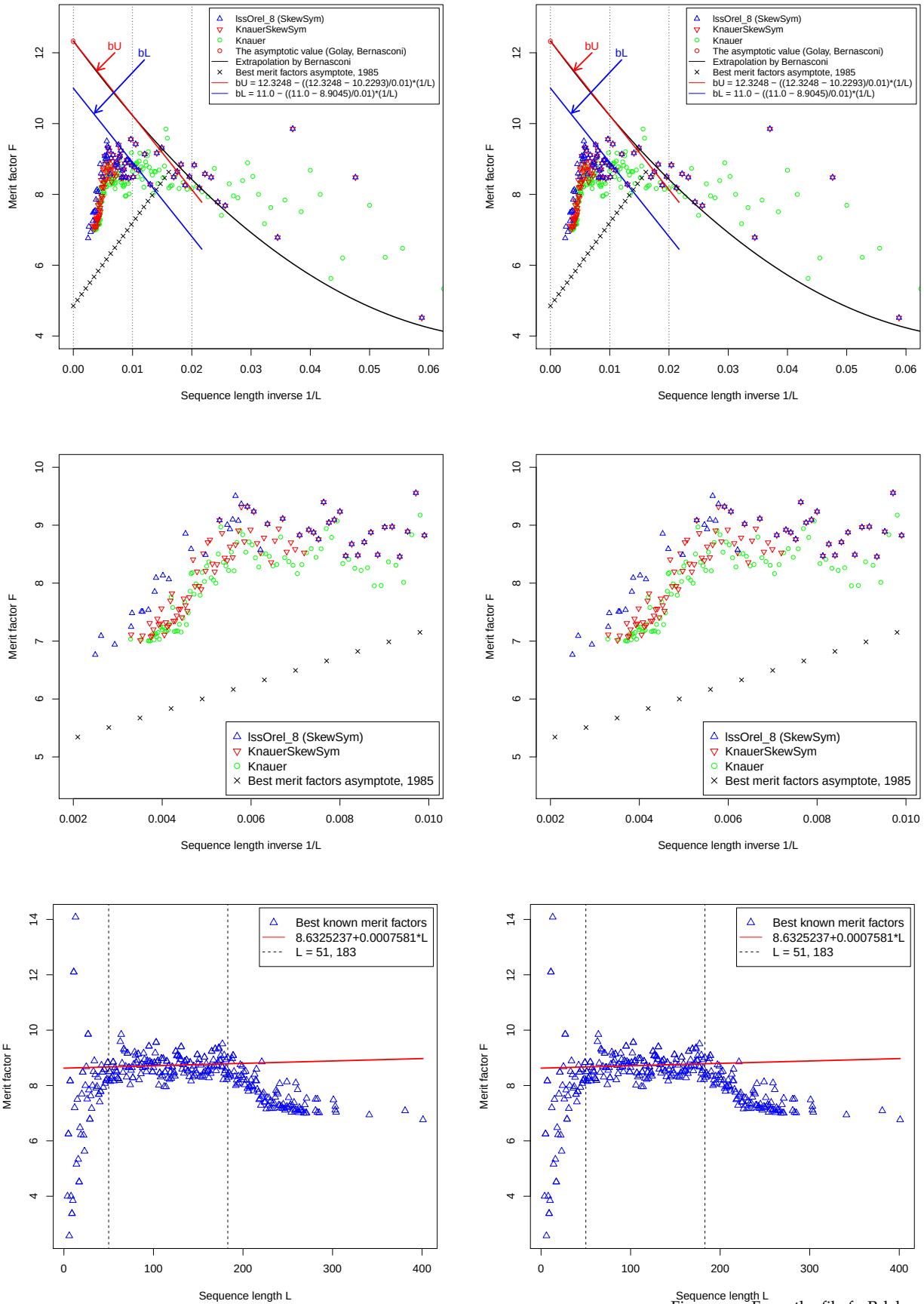


Figure 2.5: From the file fg-R-labs-wide-6-figures.tex *borrowed from* `Lib-OPUS2-labs-2015-arxiv-Boskovic`.

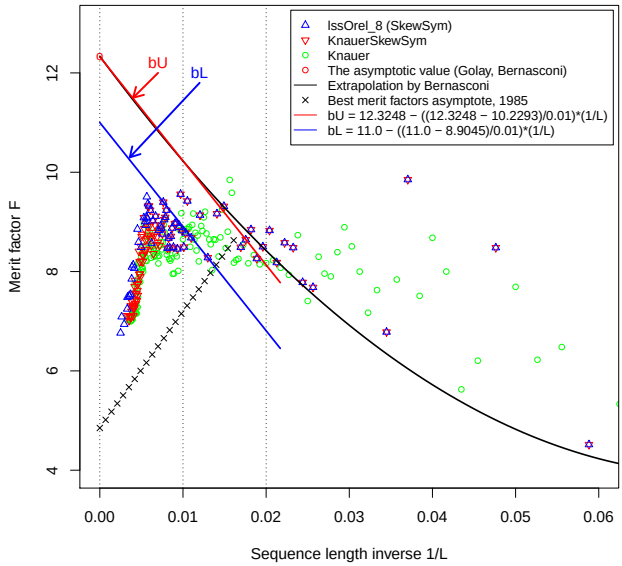
THE FILE `fg-R-labs-normal-3-figures.tex` renders Figure 2.6. **NOTE AGAIN: both 'verb' and 'cite' commands seem disabled under 'figure environment'!** Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

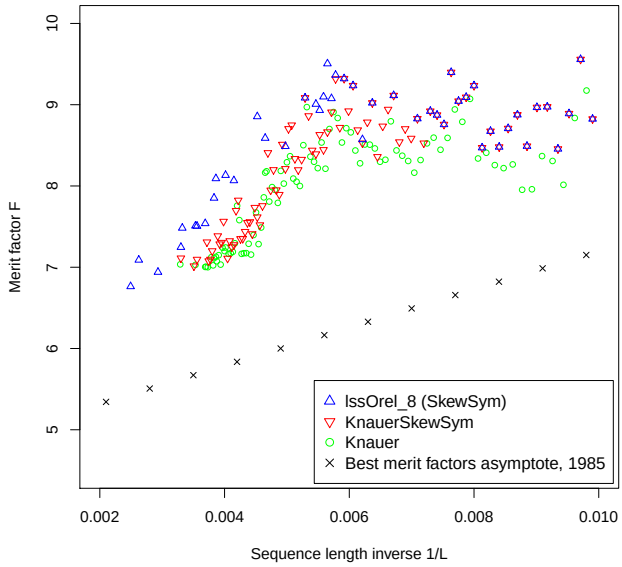
THE FILE fg-key-blackp-normal-3-figures, first used in[2], renders Figure 2.7. Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

[2] Franc Brglez, Yang Ho, and Johnny Nguyen. *On Combinatorial Optimization and Rapid Prototyping of Stochastic Solvers*. Search for eBooks under `https://github.com/fbrglez/gitPublic/` ... For edited chapters from the book, search under `http://arxiv.org/`, 2015

THE FILE fg-key-blackp-normal-1-figure.tex renders Figure 2.10. Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.





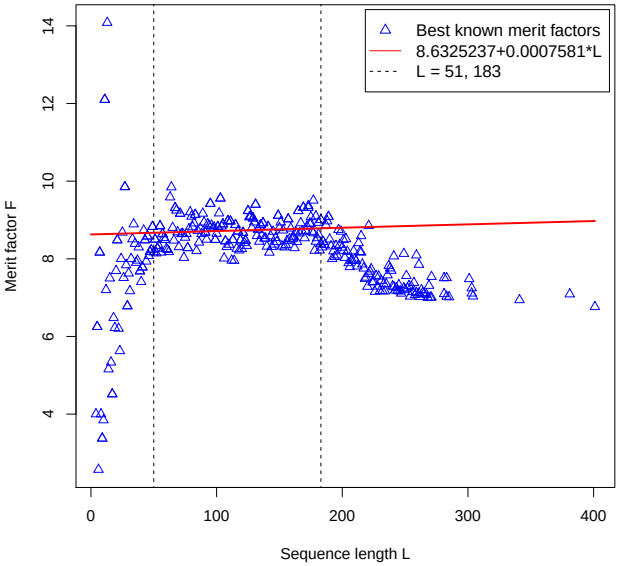


Figure 2.6: From the file fg-R-labs-normal-3-figures.tex *borrowed from* `Lib-OPUS2-labs-2015-arxiv-Boskovic`. **NOTE: both 'verb' and 'cite' commands seem disabled under 'figure environment'!** Also, 3 vertical plots in portrait from R create more white space than the 4 plots from R in wide format, see Figure 2.4. Then, (a) it may not be possible to create (a) in this file with LaTeX... may need to create it in R; (b) it may not be possible to create (b) in this file with LaTeX... may need to create it in R; (c) it may not be possible to create (c) in this file with LaTeX... may need to create it in R.

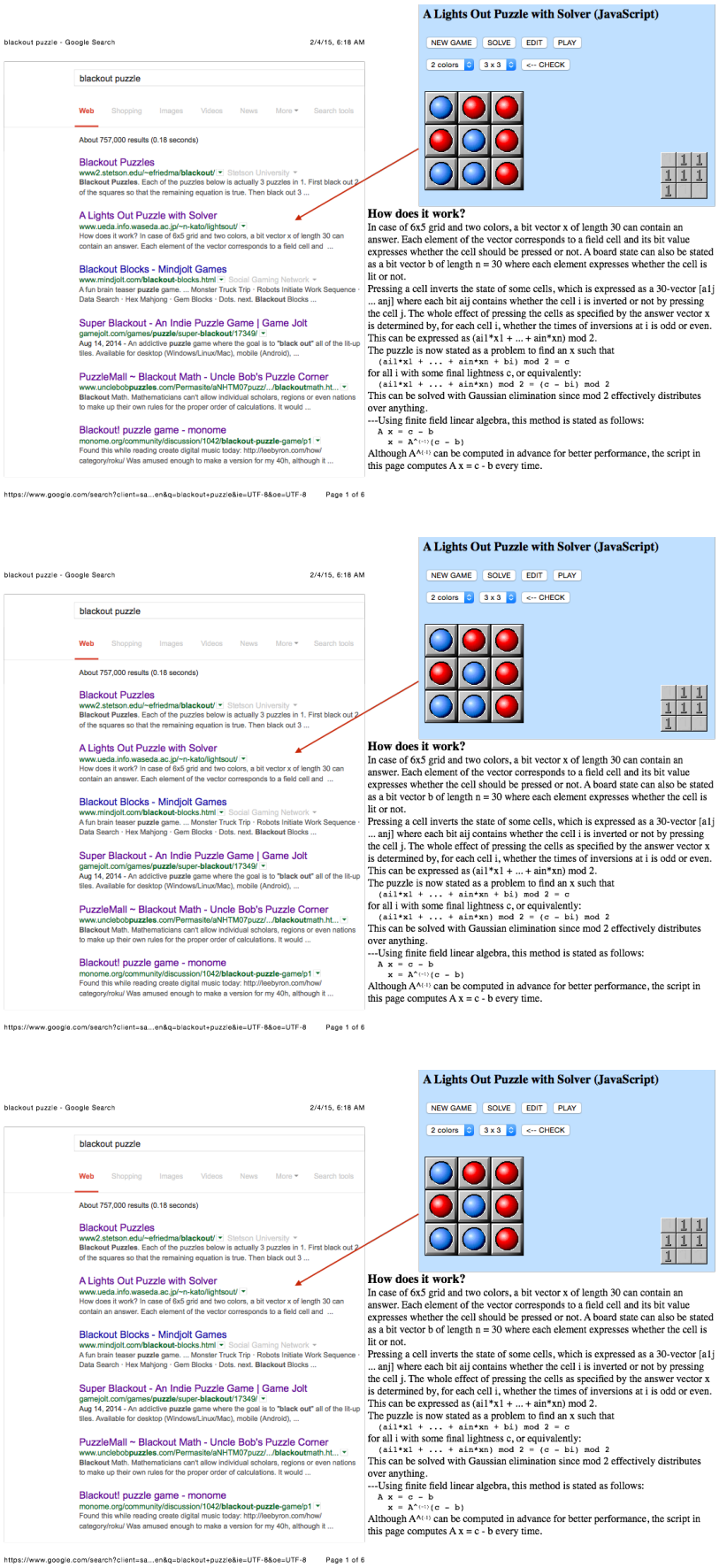


Figure 2.7: From the file fg-key-blackp-portrait-3-figures.tex *borrowed from* `Lib-OPUS2-ebook-CSC499-Sp15-2015-Brglez`. **NOTE: both 'verb' and 'cite' commands seem disabled under 'figure environment'!** Also, the portrait of 3 plots from Keynote are larger than the 3 plots from R in portrait format, see Figure **??**. Then, (a) it may not be possible to create (a) in this file with LaTeX... may need to create it in Keynote; (b) it may not be possible to create (b) in this file with LaTeX... may need to create it in Keynote; (c) it may not be possible to create (c) in this file with LaTeX... may need to create it in Keynote.

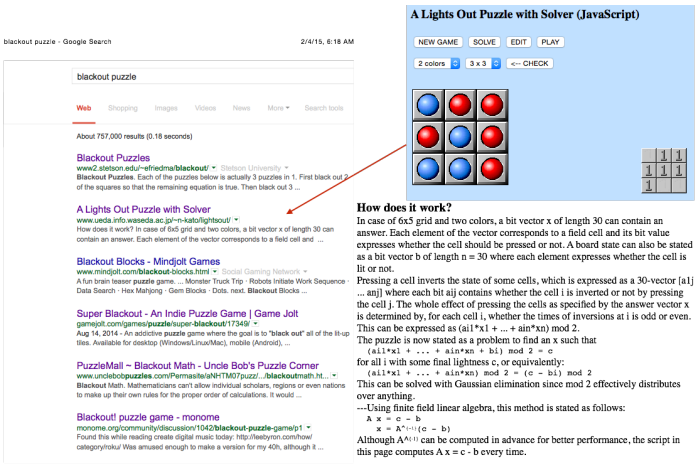


Figure 2.8: From the file fg-key-blackp-normal-2-figures.tex *borrowed from* `Lib-OPUS2-ebook-CSC499-Sp15-2015-Brglez`. **NOTE: both 'verb' and 'cite' commands seem disabled under 'figure environment'!**

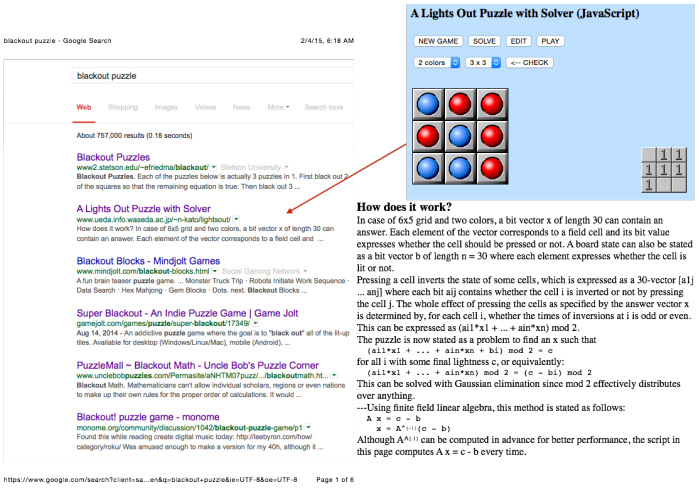


Figure 2.9: From the file fg-key-blackp-normal-2-figures.tex *borrowed from* `Lib-OPUS2-ebook-CSC499-Sp15-2015-Brglez`. **NOTE: both 'verb' and 'cite' commands seem disabled under 'figure environment'!**

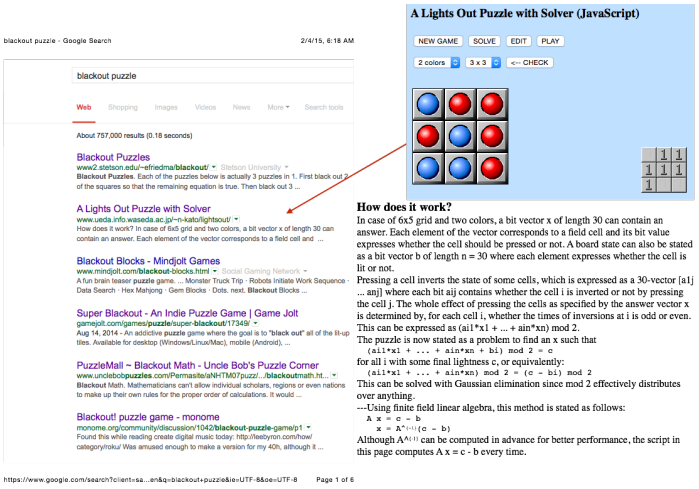


Figure 2.10: From the file fg-key-blackp-normal-2-figures.tex *borrowed from* `Lib-OPUS2-ebook-CSC499-Sp15-2015-Brglez`. **NOTE: both 'verb' and 'cite' commands seem disabled under 'figure environment'!**

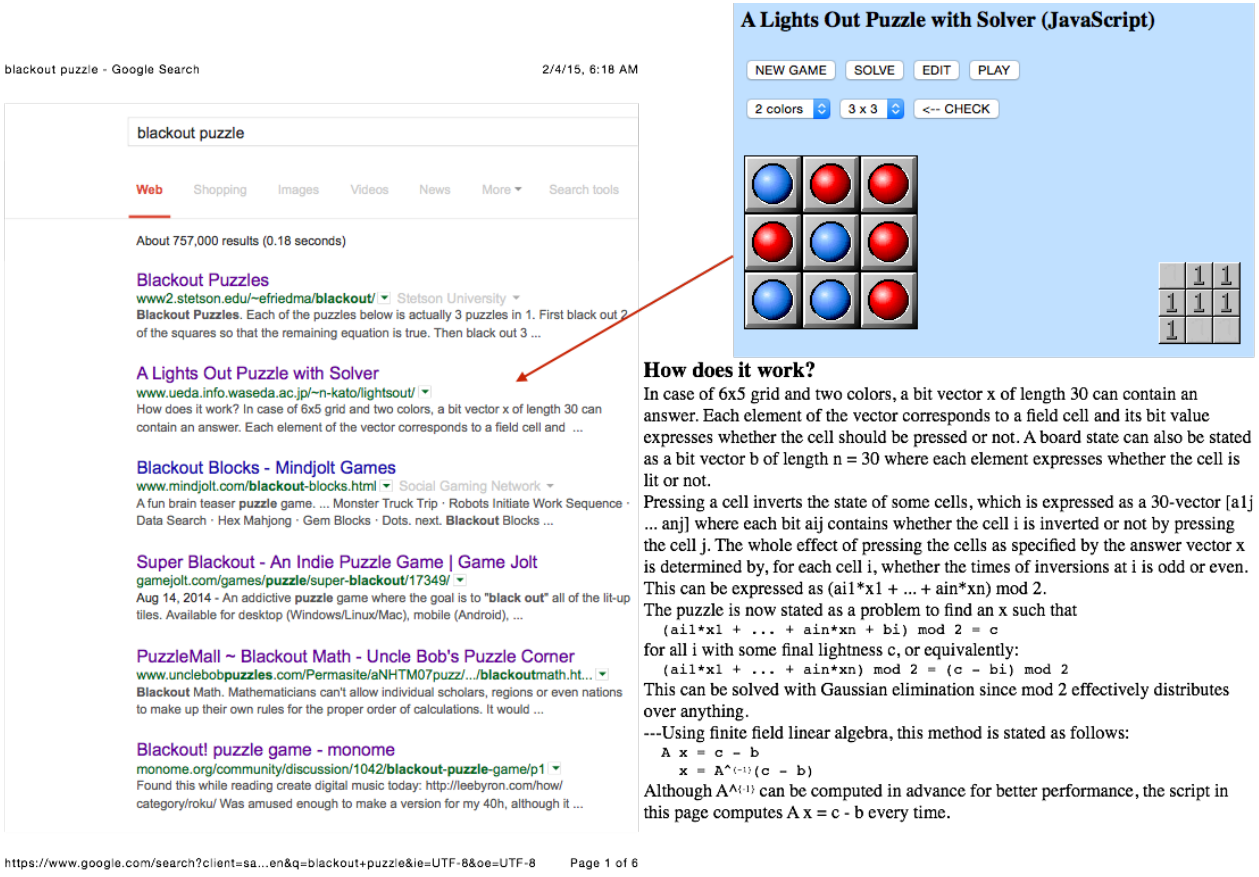
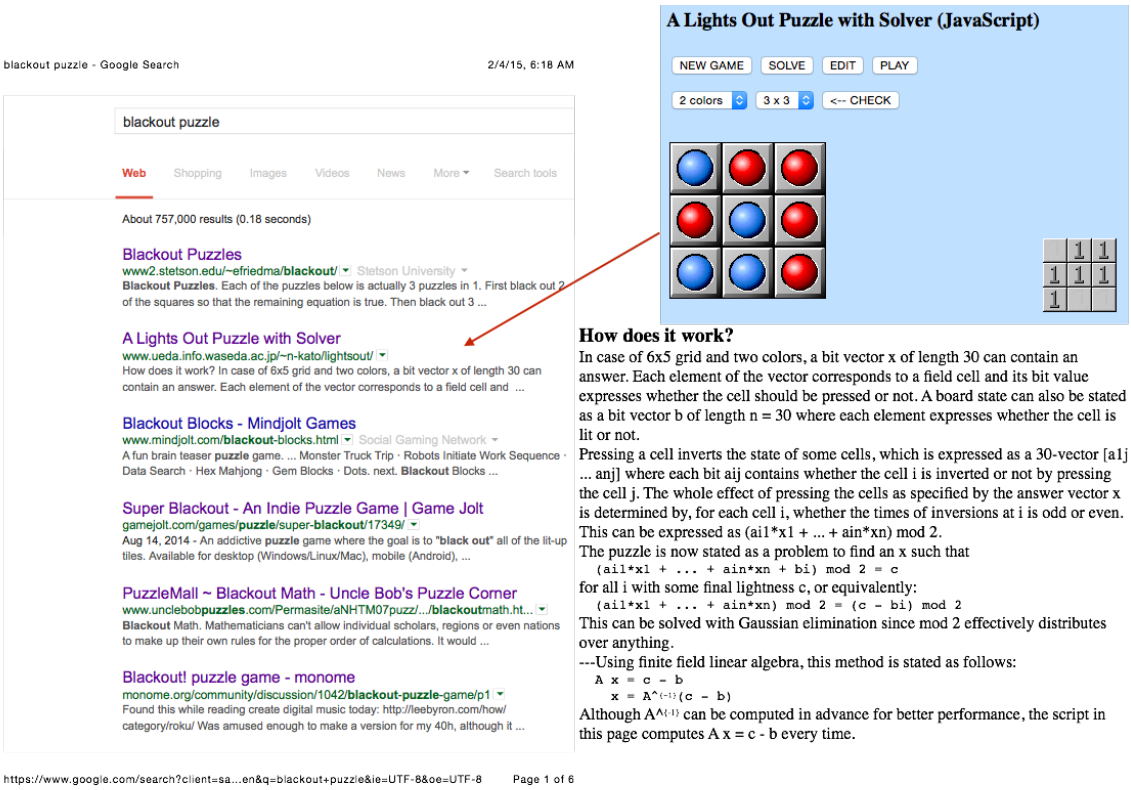


Figure 2.11: From the file fg-key-blackp-wide-1-figures.tex *borrowed from* `Lib-OPUS2-ebook-CSC499-Sp15-2015-Brglez`.

THE FILE fg-key-blackp-wide-1-figure.tex, renders Figure 2.11.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

THE FILE fg-key-blackp-wide-2-figures.tex renders Figure 2.12. The file fg-key-blackp-wide-2-figures.tex renders Figure 2.12. The file fg-key-blackp-wide-2-figures.tex renders Figure 2.12. The file fg-key-blackp-wide-2-figures.tex renders Figure 2.12. The file fg-key-blackp-wide-2-figures.tex renders Figure 2.12. The file fg-key-blackp-wide-2-figures.tex renders Figure 2.12. The file fg-key-blackp-wide-2-figures.tex renders Figure 2.12.



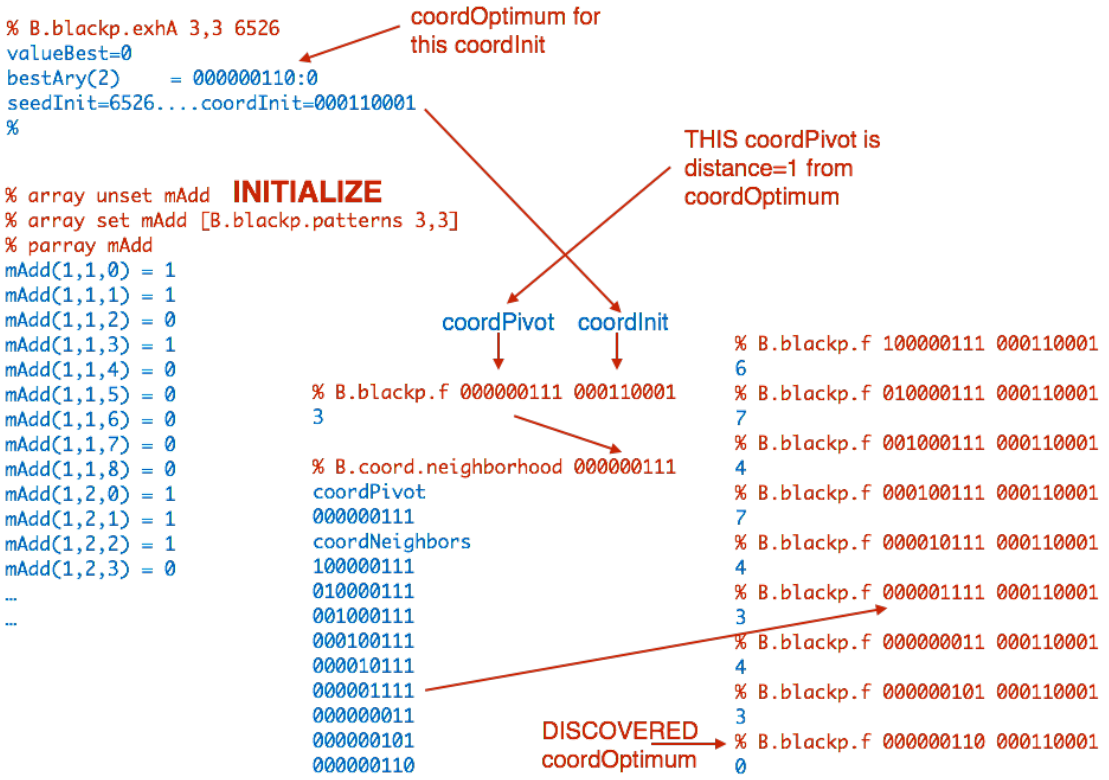


Figure 2.12: From the file fg-key-blackp-wide-2-figures.tex *borrowed from* `Lib-OPUS2-ebook-CSC499-Sp15-2015-Brglez`.

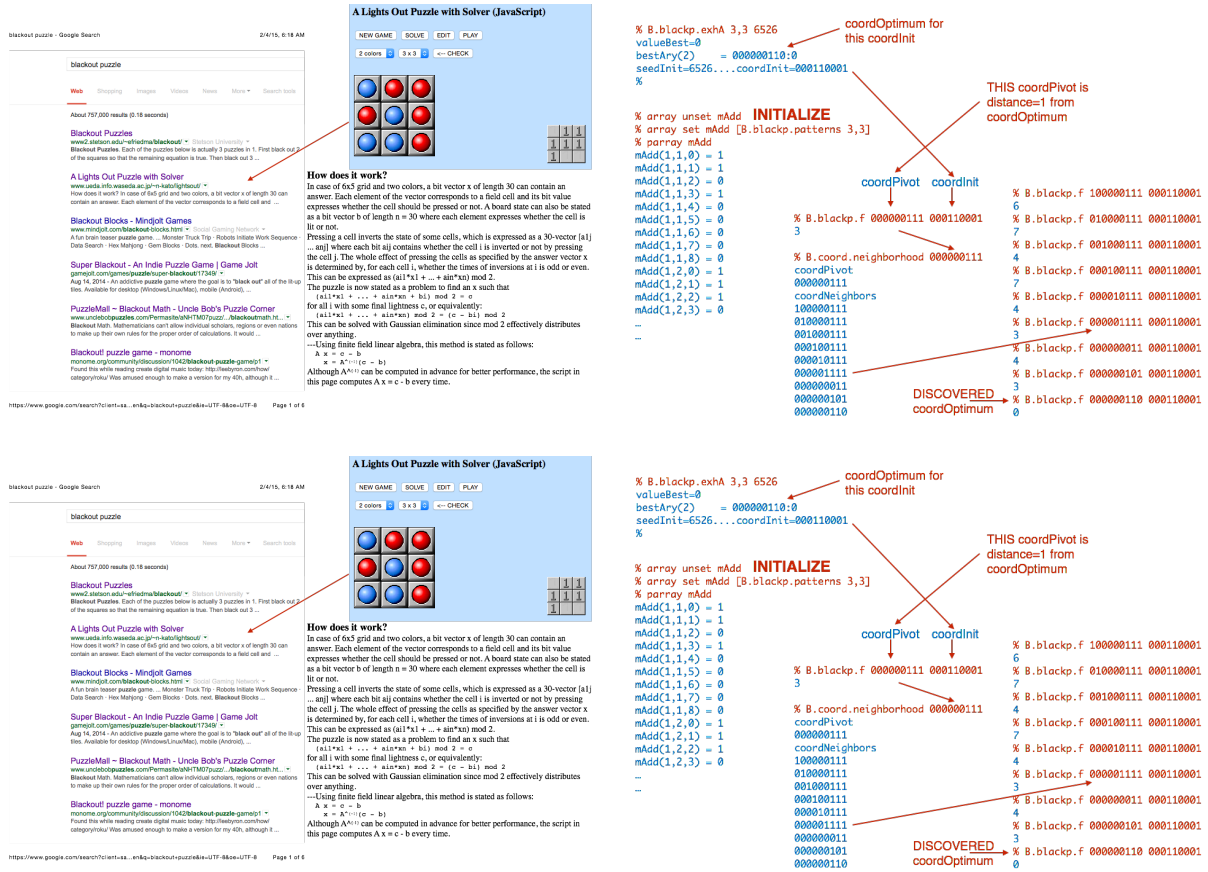


Figure 2.13: From the file fg-key-blackp-wide-4-figures.tex *borrowed from* `Lib-OPUS2-ebook-CSC499-Sp15-2015-Brglez`.

THE FILE fg-key-blackp-wide-4-figures.tex, renders Figure 2.13. Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

3
About Tables

Tables in this chapter are divided into two sections: (1) tables from Tufte, (2) tables from other sources.

For details about how various text items are being represented, see Chapter 1.

3.1 Tables from Tufte

About the tables from Tufte: Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

- a normal-width table, `tb-tufte-normal-headings`, Table 3.1,
- a normal-width table, `tb-tufte-normal-fontSizes`, Table 3.2,
- a normal-width table, `tb-tufte-normal-environmentStyles`, Table 3.3,
- a normal-width table, `tb-tufte-normal-environmentStyles`, Table 3.4, and
- a wide table, `tb-tufte-wide-extraColumn`, Table 3.5.

Heading	Style	Size
Part	roman	24/36×40 pc
Chapter	italic	20/30×40 pc
Section	italic	12/16×26 pc
Subsection	italic	11/15×26 pc
Paragraph	italic	10/14

Table 3.1: Heading styles used in *Beautiful Evidence*.

LaTeX size	Font size	Leading	Used for
`\tiny`	5	6	sidenote numbers
`\scriptsize`	7	8	–
`\footnotesize`	8	10	sidenotes, captions
`\small`	9	12	quote, quotation, and verse environments
`\normalsize`	10	14	body text
`\large`	11	15	B-heads
`\Large`	12	16	A-heads, TOC entries, author, date
`\LARGE`	14	18	handout title
`\huge`	20	30	chapter heads
`\Huge`	24	36	part titles

Table 3.2: A list of LaTeX font sizes as defined by the Tufte-LaTeX document classes.

Environment	Font size	Notes
Body text	10/14×26 pc	
Block quote	9/12×24 pc	Block indent (left and right) by 1 pc
Sidenotes	8/10×12 pc	Sidenote number is set inline, followed by word space
Captions	8/10×12 pc	

Table 3.3: Environment styles used in *Beautiful Evidence*.

Margin	Length
Paper width	8 1/2 inches
Paper height	11 inches
Textblock width	6 1/2 inches
Textblock/sidenote gutter	3/8 inches
Sidenote width	2 inches

Table 3.4: Here are the dimensions of the various margins used in the Tufte-handout class.

Environment	Font size	Notes	Extra column
Body text	10/14×26 pc		Whatever we need etc, etc, etc, etc, etc ...
Block quote	9/12×24 pc	Block indent (left and right) by 1 pc	
Sidenotes	8/10×12 pc	Sidenote number is set inline, followed by word space	
Captions	8/10×12 pc		Another item here ...

Table 3.5: Environment styles modifications used in *Beautiful Evidence*....

3.2 *Tables from Other Sources*

ABOUT THE TABLES from other sources: Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

- a wide table, `tb-tufte-wide-extraColumn`, Table 3.5 from[1], and
- a sideways table, `tb-cover-sideways-results`, Table 3.7.
  NOTE: to get the table number printed here, we had to move the label AFTER the caption!!!.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

[1] Franc Brglez and Janez Brest and Borko Bošković . *xBed: An Open Environment for Design of and Experiments with Combinatorial Solvers*. Search for eBooks under `https://github.com/fbrglez/gitPublic/` ... For edited chapters from the book, search under `http://arxiv.org/`, 2015; and Borko Bošković, Franc Brglez, and Janez Brest. Low-Autocorrelation Binary Sequences: On Improved Merit Factors and Runtime Predictions to Achieve Them. *`http://arxiv.org/`, also under journal review*, 2015

symbol	short name	brief description
L	coordDim	instance size
L'	coordDim′	instance size under skew-symmetry $(L+1)/2$
σ_0	seedInit	initial seed integer
$\underline{\varsigma}_0$	coordInit	initial coordinate
$\Theta(\underline{\varsigma}_0)$	valueInit	initial value
$\underline{\varsigma}_j$	coordPivot	pivot coordinate
$\Theta(\underline{\varsigma}_j)$	valuePivot	pivot value
$\underline{\varsigma}_j^i$	coordNeighb	pivot neighbor coord.
$\mathcal{N}(\underline{\varsigma}_j)$	coordNeighbSet	full neighborhood set of pivot coordinate
$\mathcal{N}_{saw}(\underline{\varsigma}_j)$	sawNeighbSet	SAW neighborhood set
ω_c	walkSegmCoef	walk segment coefficient
$\omega_{lmt} = \omega_c \times L'$	walkSegmLmt	walk segm. length limit
$Walk_\omega = = \{\underline{\varsigma}_0, \ldots, \underline{\varsigma}_\omega\}$	walkList	walk list after ω steps

For `labs` problems with an odd value of L, $L' = (L+1)/2$ represents a *de facto* instance size under skew-symmetry.

symbol	short name	brief description
t	runtime	CPU runtime
t_{lmt}	runtimeLmt	solver timeout value
τ	cntProbe	# of function probes
ρ	cntRestart	# of walk restarts
β	cntTrapped	# of trapped solutions
$\underline{\varsigma}^*$	coordBest	best coordinate
$\Theta(\underline{\varsigma}^*)$	valueBest	best value
Θ_L^{ub}	valueTarget	best upper bound
	isCensored	solution status: 1 if $t >= t_{lmt}$; 0 otherwise
	targetReached	solution status: 0 if $\Theta(\underline{\varsigma}^*) > \Theta_L^{ub}$, 1 if $\Theta(\underline{\varsigma}^*) = \Theta_L^{ub}$, 2 if $\Theta(\underline{\varsigma}^*) < \Theta_L^{ub}$
N	sampleSize	# of instances and initial seeds in the experiment
$\mathcal{H}(sid, \Theta_L^{ub})$	hitRatio	# of uncensored solutions under targetReached = 1 divided by sampleSize N
$\mathcal{S}(sid, \Theta_L^{ub}, p)$	asymptotic solvability	predicted waiting time to satisfy $\mathcal{H}(...) = 1$ with solver *sid*, probability p

For `labs` problems, $\Theta(\underline{\varsigma}^*)$ represents the *minimum energy value* returned by the solver.

Table 3.6: Summary of notation: symbols, names, and descriptions.

Table 3.7: A statistical summary of experimental results. For each instance, sample size ≤ 100 as shown column *ss2cf* (as the first number).

								SAW method = wanderU						SAW method = meanderU							
								walkL		cntProbe			runtime			walkL		cntProbe			runtime
instance	**cols**	**rows**	**vBK**	**vBest**	**card**	**ss2cf**	**hitR**	**mean**	**med**	**mean**	**std**	**speed**	**runLmt**	**ss2cr**	**hitR**	**mean**	**med**	**mean**	**std**	**speed**	**runLmt**
unate/steinerU cite																					
i-045.cnf	45	330	30*	30	10	100/0	1.00	2.20e+4	8.44e+5	9.89e+5	9.08e+5	7.24e+5	7.9	100/0	1.00	1.65e+4	2.87e+5	3.78e+5	3.41e+5	6.04e+5	3.6
i-081.cnfU	81	1080	61*	61	196	100/0	1.00	4.92e+3	2.73e+5	3.98e+5	4.13e+5	2.65e+6	1.1	100/4	0.96	8.00e+4	2.02e+6	3.22e+6	4.04e+6	4.00e+5	36.0
i-135.cnfU	135	3015	103*	103	40	100/45	0.55	1.06e+9	1.49e+11	1.42e+11	8.15e+10	1.19e+6	172800.0	NA	NA	NA	NA	NA	NA	NA	NA
i-243.cnfU	243	9801	198*	198	56	100/44	0.56	1.08e+7	1.73e+9	2.62e+9	2.72e+9	8.26e+5	7200.0	NA	NA	NA	NA	NA	NA	NA	NA
i-405.cnfU	405	27270	335	NA	NA	NA	NA	NA	NA	NA	NA	NA	259200.0	NA	NA	NA	NA	NA	NA	NA	NA
i-729.cnfU	729	88452	617	617	54	78/24	0.69	1.61e+7	6.97e+9	1.17e+10	1.35e+10	1.84e+5	259200.0	NA	NA	NA	NA	NA	NA	NA	NA
unate/LogSynthU cite																					
max1024.cnfU	1264	1090	245*	NA	NA	57/57	0.00	1.28e+7	1.62e+10	1.62e+10	1.70e+7	4.50e+6	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
max1024.pi.cnfU	1278	1087	259*	NA	NA	56/56	0.00	1.26e+7	1.62e+10	1.62e+10	4.43e+7	4.50e+6	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
ex5.cnfU	2428	831	37*	37	86	100/14	0.86	2.47e+6	5.47e+9	6.01e+9	4.07e+9	3.70e+6	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
ex5.pi.cnfU	2459	873	65*	65	84	100/16	0.84	2.28e+6	4.51e+9	5.61e+9	4.01e+9	3.73e+6	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
prom2.cnfU	2611	1924	278*	278	50	100/0	1.00	2.48e+5	5.12e+8	6.48e+8	4.19e+8	5.90e+6	587.6	NA	NA	NA	NA	NA	NA	NA	NA
prom2.pi.cnfU	2617	1988	287*	287	58	100/0	1.00	2.62e+5	6.09e+8	6.86e+8	3.75e+8	5.91e+6	486.9	NA	NA	NA	NA	NA	NA	NA	NA
bench1.pi.cnfU	4676	398	121*	NA	NA	48/48	0.00	3.58e+6	1.67e+10	1.67e+10	6.58e+7	4.65e+6	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
exam.pi.cnfU	4676	509	63*	NA	NA	NA	NA	NA	NA	NA	NA	NA	172800.0	NA	NA	NA	NA	NA	NA	NA	NA
test4.pi.cnfU	6139	1437	101	101	39	100/39	0.61	1.04e+6	6.10e+9	6.42e+9	3.40e+9	3.00e+6	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
binate/LogSynthB cite																					
clip.b.cnf	349	707	15*	15	199	100/0	1.00	1.28e+4	3.08e+6	4.46e+6	4.97e+6	1.91e+6	18.7	100/0	1.00	1.64e+3	2.20e+5	2.89e+5	3.02e+5	2.07e+6	1.5
sao2.b.cnf	372	772	25*	25	100	43/43	0.00	1.78e+6	6.65e+8	6.61e+8	1.42e+7	1.10e+6	600.0	100/0	1.00	2.61e+5	2.99e+7	4.87e+7	4.76e+7	1.21e+6	277.6
f51m.b.cnf	406	520	NA	18	199	100/0	1.00	4.05e+3	1.21e+6	1.64e+6	1.30e+6	2.17e+6	3.6	100/0	1.00	9.26e+2	1.36e+5	1.88e+5	1.81e+5	1.89e+6	1.2
5xp1.b.cnf	464	845	12*	12	146	100/9	0.91	8.47e+4	3.44e+7	3.93e+7	2.92e+7	1.70e+6	60.0	100/0	1.00	1.32e+3	2.02e+5	3.08e+5	3.08e+5	2.17e+6	0.7
count.b.cnf	466	694	24*	24	199	100/0	1.00	1.12e+4	3.81e+6	5.22e+6	4.38e+6	1.90e+6	13.3	100/0	1.00	5.90e+2	9.32e+4	1.38e+5	1.29e+5	2.03e+6	0.4
e64.b.cnf	607	1022	48	47	124	70/46	0.34	1.24e+6	9.22e+8	7.56e+8	2.95e+8	1.08e+6	900.0	100/0	1.00	6.91e+3	1.61e+6	2.10e+6	1.84e+6	1.92e+6	6.2
alu4.cnf	807	1823	50*	50	128	100/72	0.28	7.64e+4	7.38e+7	6.16e+7	2.27e+7	1.26e+6	60.0	100/0	1.00	1.20e+4	3.90e+6	4.85e+6	3.78e+6	1.28e+6	19.9
rot.b.cnf	1451	2932	115*	115	22	3/3	0.00	NA	NA	NA	NA	NA	1800.0	56/34	0.39	1.65e+6	1.47e+9	1.20e+9	4.68e+8	8.60e+5	1800.0
binate/uf cite																					
uf250-001.cnf	250	1065	108	108	1	47/47	0.00	8.06e+6	1.97e+9	1.98e+9	4.65e+7	1.10e+6	1800.0	50/46	0.08	2.13e+7	2.82e+9	2.67e+9	5.63e+8	1.57e+6	1800.0
uf250-019.cnf	250	1065	96	96	18	53/44	0.17	1.00e+7	2.90e+9	2.47e+9	1.04e+9	1.71e+6	1800.0	52/0	1.00	1.32e+6	9.14e+7	1.65e+8	2.61e+8	1.43e+6	1373.1
uf250-027.cnf	250	1065	104	105	NA	46/46	0.00	1.26e+7	3.11e+9	3.11e+9	7.28e+7	1.72e+6	1800.0	31/31	0.00	1.60e+7	2.01e+9	2.01e+9	4.37e+7	1.11e+6	1800.0
uf250-034.cnf	250	1065	115	115	3	48/46	0.04	1.20e+7	3.08e+9	2.96e+9	6.24e+8	1.74e+6	1800.0	47/45	0.04	2.12e+7	2.78e+9	2.66e+9	5.60e+8	1.55e+6	1800.0
uf250-087.cnf	250	1065	110	110	6	46/46	0.00	1.28e+7	3.15e+9	3.14e+9	8.04e+7	1.74e+6	1800.0	55/47	0.15	1.38e+7	2.01e+9	1.73e+9	6.75e+8	1.13e+6	1800.0
binate/factoring cite																					
i-54-f2-09.cnf	54	224	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
i-54-f2-10.cnf	54	224	9	NA	NA	NA	NA	NA	NA	NA	NA	NA	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
i-54-f2-15.cnf	54	224	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
i-118-f2-33.cnf	118	548	19	NA	NA	NA	NA	NA	NA	NA	NA	NA	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
i-163-f2-91.cnf	163	777	29	NA	NA	NA	NA	NA	NA	NA	NA	NA	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
i-271-f2-303.cnf	271	1333	28	NA	NA	NA	NA	NA	NA	NA	NA	NA	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
i-328-f2-707.cnf	328	1640	1655	NA	NA	NA	NA	NA	NA	NA	NA	NA	3600.0	NA	NA	NA	NA	NA	NA	NA	NA
i-403-f2-1111.cnf	403	2029	2021	NA	NA	NA	NA	NA	NA	NA	NA	NA	3600.0	NA	NA	NA	NA	NA	NA	NA	NA

4
More About Algorithms

Algorithms in this chapter have been created for further testing of this template. Currently, we expect algorithms placed into different chapters to have a running counter that spans all chapters – unlike Figures and Tables that have a two part counter: `byChapter.byInCapterCounter`.

Question is: can the template be tweaked to generate algorithm counter in the same style as we have for Figures and Tables.

In addition: we also illustrate two algorithms that are embedded into the figures environment.

The example of Algorithm 7 is normal width on a half-page. The example of Algorithm 8 is full width on a half-page.

The example of Figure 4.1 is in two columns on a half-page. The example of Figure 4.2 is in two columns on a full-page. The figure environment can clearly be used to reference the any algorithm within the figure environment.

Some more text follows. Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Algorithm 7 Procedure newPivot2.saw – normal width.

procedure `newPivot.saw`($\underline{\varsigma}_{\omega_s-1}, Walk_{\omega_s-1}$)
  $\mathbb{Z} \leftarrow i = 1, 2, \ldots, L$
  $\mathbb{Z}_p \leftarrow permute(\mathbb{Z})$
  $\mathcal{N}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\underline{\varsigma}^i_{\omega_s-1} | d(\underline{\varsigma}_{\omega_s-1}, \underline{\varsigma}^i_{\omega_s-1}) = 1, i \in \mathbb{Z}_p\}$
  $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\mathcal{N}(\underline{\varsigma}_{\omega-1}) | \underline{\varsigma}^i_{\omega_s-1} \notin Walk_{\omega_s-1}\}$
  if $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \neq \emptyset$ **then**
    $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `bestNeighbor`$(\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}))$
    $Walk_{\omega_s} \leftarrow Walk_{\omega_s-1} \cup \{\underline{\varsigma}_{\omega_s}\}$
    $\tau \leftarrow \tau + |\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1})|$ ▷ update *cntProbe*
  else ▷ **deal with a trapped pivot**
    $\beta = \beta + 1$
    $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `coordInit`() ▷ re-initialize
    $Walk_{\omega_s} \leftarrow \{\underline{\varsigma}_{\omega_s}\}$
    $\tau \leftarrow \tau + 1$ ▷ update *cntProbe*
  end if
  return $Walk_{\omega_s} : \underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s})$
end procedure

Algorithm 8 Procedure newPivot2.saw – using algorithm-wide environment.

procedure `newPivot.saw`($\underline{\varsigma}_{\omega_s-1}, Walk_{\omega_s-1}$)
  $\mathbb{Z} \leftarrow i = 1, 2, \ldots, L$
  $\mathbb{Z}_p \leftarrow permute(\mathbb{Z})$
  $\mathcal{N}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\underline{\varsigma}^i_{\omega_s-1} | d(\underline{\varsigma}_{\omega_s-1}, \underline{\varsigma}^i_{\omega_s-1}) = 1, i \in \mathbb{Z}_p\}$
  $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \leftarrow \{\mathcal{N}(\underline{\varsigma}_{\omega-1}) | \underline{\varsigma}^i_{\omega_s-1} \notin Walk_{\omega_s-1}\}$
  if $\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}) \neq \emptyset$ **then**
    $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `bestNeighbor`$(\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1}))$
    $Walk_{\omega_s} \leftarrow Walk_{\omega_s-1} \cup \{\underline{\varsigma}_{\omega_s}\}$
    $\tau \leftarrow \tau + |\mathcal{N}_{saw}(\underline{\varsigma}_{\omega_s-1})|$ ▷ update *cntProbe*
  else ▷ **deal with a trapped pivot**
    $\beta = \beta + 1$
    $\underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s}) \leftarrow$ `coordInit`() ▷ re-initialize
    $Walk_{\omega_s} \leftarrow \{\underline{\varsigma}_{\omega_s}\}$
    $\tau \leftarrow \tau + 1$ ▷ update *cntProbe*
  end if
  return $Walk_{\omega_s} : \underline{\varsigma}_{\omega_s} : \Theta(\underline{\varsigma}_{\omega_s})$
end procedure

```
1: procedure lssMAts(Θ_L^ub, t_lmt)
2:   for i ← 1 to popsize do
3:     pop_i ← RandomBinarySequence(L)
4:     Evaluate(pop_i)
5:   end for
6:   Θ(ς*)← ValueBest(pop)
7:   while t < t_lmt and Θ(ς*) > Θ_L^ub do
8:     for i = 1 to offsize do
9:       if recombination is performed (p_X) then
10:        parent_1 ←Select(pop)
11:        parent_2 ←Select(pop)
12:        offspring_i ←Recombine(parent_1, parent_2)
13:      else
14:        offspring_i ←Select(pop)
15:      end if
16:      if mutation is performed (p_m) then
17:        offspring_i ←Mutate(offspring_i)
18:      end if
19:      offspring_i ←TabuSearch(offspring_i)
20:      Evaluate(offspring_i)
21:    end for
22:    pop ←Replace(pop, offspring)
23:    Θ(ς*)← ValueBest(pop)
24:  end while
25: end procedure
```

The procedure `lssMAts` on the left is an instrumented versions of the `labs` solver named as MA_{TS} in cite *Lib-OPUS-labs-2009-ASC-Gallardo-memetic*. Settings of all parameters, used also in our experiments, are described in cite *Lib-OPUS-labs-2009-ASC-Gallardo-memetic*. See a concise reprise below.

setting	value
population size:	100
mutation probability:	$2/(L+1)$
crossover probability:	0.9
tournament selection size:	2
crossover:	uniform
tabu search walk length:	a random choice from the range $[\frac{L}{2}, \frac{3L}{2}]$

```
1: procedure lssRRts(Θ_L^ub, t_lmt)
2:   pop_1 ← RandomBinarySequence(L)
3:   Evaluate(pop_1)
4:   Θ(ς*)← ValueBest(pop)
5:   while t < t_lmt and Θ(ς*) > Θ_L^ub do
6:     pop_1 ←RandomBinarySequence(L)
7:     pop_1 ←TabuSearch(pop_1)
8:     Evaluate(pop_1)
9:     Θ(ς*)← ValueBest(pop)
10:  end while
11: end procedure
```

Figure 4.1: We illustrate two instrumented versions of the `labs` solver named as MA_{TS} in cite *Lib-OPUS-labs-2009-ASC-Gallardo-memetic* under the caption "Pseudo code of the memetic algorithm".

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

```
1: procedure lss0rel(σ_0, Θ_L^ub, t_lmt, ω_lmt)
2:   ς_0:Θ(ς_0) ← coordInit(σ_0)                          ▷ initial solution
3:   τ ← 1                                                 ▷ initialize cntProbe
4:   ς*:Θ(ς*) ← ς_0:Θ(ς_0)                                 ▷ initial best solution
5:   isCens ← 0                                            ▷ initialize isCensored
6:   tgReached ← 0                                         ▷ initialize targetReached
7:   β ← 0                                                 ▷ initialize cntTrapped
8:   ω ← 0                                                 ▷ initialize total number of steps
9:   while true do
10:    ω_s:ς*:Θ(ς*) ← walk.saw(ς_0:Θ(ς_0), t_lmt, ω_lmt)  ▷ return a completed walk segment
11:    ω ← ω + ω_s                                         ▷ update total number of steps
12:    if Θ(ς*) ≤ Θ_L^ub then
13:      if Θ(ς*) = Θ_L^ub then
14:        tgReached = 1                                   ▷ upper-bound is reached
15:      else
16:        tgReached = 2                                   ▷ upper-bound is improved
17:      end if
18:      break
19:    end if
20:    if t ≥ t_lmt then
21:      isCens ← 1                                        ▷ return solution as "censored"
22:      break
23:    end if
24:    ς_0:Θ(ς_0) ← coordInit()                            ▷ initialize a new walk segment
25:    τ ← τ + 1                                           ▷ update cntProbe
26:    ω ← ω + 1                                           ▷ update total number of steps
27:  end while
28:  Table ← (σ_0, ς*, Θ(ς*), ω, τ, t, isCens, tgReached)
29: end procedure
```

```
1: procedure walk.saw(ς_0:Θ(ς_0), t_lmt, ω_lmt)
2:   if Θ(ς_0) ≤ Θ(ς*) then
3:     ς*:Θ(ς*) ← ς_0:Θ(ς_0)        ▷ new best solution
4:   end if
5:   ω_s ← 0                        ▷ walk segment length
6:   Walk_0 ← {ς_0}                 ▷ new walk segment
7:   while Θ(ς*) > Θ_L^ub and ω_s < ω_lmt do
8:     if t ≥ t_lmt then            ▷ timeout
9:       break
10:    end if
11:    ω_s = ω_s + 1                ▷ a new step!
12:    Walk_ω_s:ς_ω_s:Θ(ς_ω_s) ←
13:        ← newPivot.saw(ς_ω_s−1, Walk_ω_s−1)
14:    if Θ(ς_ω_s) ≤ Θ(ς*) then
15:      ς*:Θ(ς*) ← ς_ω_s:Θ(ς_ω_s)
16:    end if
17:  end while
18:  return ω_s:ς*:Θ(ς*)
19: end procedure
```

```
1: procedure newPivot.saw(ς_ω_s−1, Walk_ω_s−1)
2:   ℤ ← i = 1, 2, ..., L
3:   ℤ_p ← permute(ℤ)
4:   𝒩(ς_ω_s−1) ← {ς^i_ω_s−1 | d(ς_ω_s−1, ς^i_ω_s−1) = 1, i ∈ ℤ_p}
5:   𝒩_saw(ς_ω_s−1) ← {𝒩(ς_ω−1) | ς^i_ω_s−1 ∉ Walk_ω_s−1}
6:   if 𝒩_saw(ς_ω_s−1) ≠ ∅ then
7:     ς_ω_s:Θ(ς_ω_s) ← bestNeighbor(𝒩_saw(ς_ω_s−1))
8:     Walk_ω_s ← Walk_ω_s−1 ∪ {ς_ω_s}
9:     τ ← τ + | 𝒩_saw(ς_ω_s−1) |   ▷ update cntProbe
10:  else                          ▷ deal with a trapped pivot
11:    β = β + 1
12:    ς_ω_s:Θ(ς_ω_s) ← coordInit()   ▷ re-initialize
13:    Walk_ω_s ← {ς_ω_s}
14:    τ ← τ + 1                   ▷ update cntProbe
15:  end if
16:  return Walk_ω_s:ς_ω_s:Θ(ς_ω_s)
17: end procedure
```

Figure 4.2: A fully instrumented version of solver `lss0rel` and two supporting procedures.

Bibliography

[1] Franc Brglez. GitHub Archive on Rapid Prototyping of Combinatorial Solvers. For updates, see https://github.com/fbrglez/gitPublic, January 2015.

[2] Robert Bringhurst. *The Elements of Typography*. Hartley & Marks, 3.1 edition, 2005.

[3] Edward R. Tufte. *Beautiful Evidence*. Graphics Press, LLC, first edition, May 2006.

[4] Edward R. Tufte. *Envisioning Information*. Graphics Press, Cheshire, Connecticut, 1990.

[5] Borko Bošković, Franc Brglez, and Janez Brest. Low-Autocorrelation Binary Sequences: On Improved Merit Factors and Runtime Predictions to Achieve Them. *http://arxiv.org/*, *also under journal review*, 2015.

[6] Marcel J.E. Golay. Sieves for low autocorrelation binary sequences. *IEEE: Transactions on Information Theory*, 23:43–51, 1977.

[7] Marcel J.E. Golay. The merit factor of long low autocorrelation binary sequences. *IEEE: Transactions on Information Theory*, 28:543–549, 1982.

[8] Marcel J.E. Golay and Duncan B. Harris. A new search for skewsymmetric binary sequences with optimal merit factors. *Information Theory, IEEE Transactions on*, 36(5):1163–1166, 1990.

[9] Jacob Bernasconi. Low autocorrelation binary sequences: statistical mechanics and configuration space analysis. *J. Phys.*, 48:559–567, April 1987.

[10] Martin Pelikan and David E. Goldberg. Hierarchical boa solves ising spin glasses and maxsat. In *Proceedings of the 2003 international conference on Genetic and evolutionary computation: PartII*, GECCO'03, pages 1271–1282, Berlin, Heidelberg, 2003. Springer-Verlag.

[11] Stephan Mertens. Exhaustive search for low-autocorrelation binary sequences. *Journal of Physics A: Mathematical and General*, 29:473–481, 1996. The sequences for 48 < L <= 60 have been found with an improved implementation due to Heiko Bauke. All values are available at http://www-e.uni-magdeburg.de/mertens/research/labs/open.dat.

[12] LABS Problem: 2002 Merit Factor Records posted by Knauer. Now re-posted under two mirrroring sites: http://cbl.ncsu.edu/xBed/xProj/B.labs/ and http://labraj.uni-mb.si/en/B.labs, 2014.

[13] G.F.M. Beenker, T.A.C.M. Claasen, and P.W.C. Hermens. Binary sequences with a maximally flat amplitude spectrum. *Philips J. Res.*, vol. 40:289–304, 1985.

[14] Franc Brglez, Janez Brest, and Borko Bošković. Home Page of the LABS Problem Performance Experiments and Solutions. Posted under two mirrroring sites: http://cbl.ncsu.edu/xBed/xProj/B.labs/ and http://labraj.uni-mb.si/en/B.labs, 2014.

[15] Franc Brglez, Yang Ho, and Johnny Nguyen. *On Combinatorial Optimization and Rapid Prototyping of Stochastic Solvers*. Search for eBooks under https://github.com/fbrglez/gitPublic/ ... For edited chapters from the book, search under http://arxiv.org/, 2015.

[16] Franc Brglez and Janez Brest and Borko Bošković . *xBed: An Open Environment for Design of and Experiments with Combinatorial Solvers*. Search for eBooks under https://github.com/fbrglez/gitPublic/ ... For edited chapters from the book, search under http://arxiv.org/, 2015.