External Labeling

Fundamental Concepts and Algorithmic Techniques

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External Labeling

Fundamental Concepts and Algorithmic Techniques

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ABSTRACT

This book focuses on techniques for automating the procedure of creating external labelings, also known as *callout labelings*. In this labeling type, the features within an illustration are connected by thin leader lines (called *leaders*) with their labels, which are placed in the empty space surrounding the image.

In general, textual labels describing graphical features in maps, technical illustrations (such as assembly instructions or cutaway illustrations), or anatomy drawings are an important aspect of visualization that convey information on the objects of the visualization and help the reader understand what is being displayed.

Most labeling techniques can be classified into two main categories depending on the "distance" of the labels to their associated features. *Internal labels* are placed inside or in the direct neighborhood of features, while *external labels*, which form the topic of this book, are placed in the margins outside the illustration, where they do not occlude the illustration itself. Both approaches form well-studied topics in diverse areas of computer science with several important milestones.

The goal of this book is twofold. The first is to serve as an entry point for the interested reader who wants to get familiar with the basic concepts of external labeling, as it introduces a unified and extensible taxonomy of labeling models suitable for a wide range of applications. The second is to serve as a point of reference for more experienced people in the field, as it brings forth a comprehensive overview of a wide range of approaches to produce external labelings that are efficient either in terms of different algorithmic optimization criteria or in terms of their usability in specific application domains. The book mostly concentrates on algorithmic aspects of external labeling, but it also presents various visual aspects that affect the aesthetic quality and usability of external labeling.

KEYWORDS

- external labeling: boundary, contour, excentric, static, dynamic
- points, features, leaders, labels, callouts
- taxonomy, quality metrics, optimization, algorithmic techniques

Contents

Preface

This book is the final outcome of continuing discussions among the three authors regarding the growing body of literature on the topic of external labeling that we were facing when discussing related work in several of our own articles on the topic. Accordingly, in March 2018, we started to intensify our discussions and collected and structured the related literature with the first goal to write a state-of-the-art report for the EuroVis conference in Lisbon in 2019. Shortly after presenting our survey at the conference, we were contacted by Niklas Elmqvist and David Ebert, editors of this *Synthesis Lectures in Visualization* series. They invited us to extend our compact survey paper into a comprehensive book and the result of this project is in your hands now.

The field of external labeling is mature enough to warrant a comprehensive handbook as a resource both for researchers with first experience in external labeling who want to broaden their knowledge, as well as for new students and researchers coming across problems in their research that relate to external labeling. However, we also believe that practitioners and domain experts who are in need of finding and implementing suitable labeling algorithms for their instances at hand or who want to obtain a deeper understanding of the strengths and weaknesses of their currently used methods will find value in this book and its introduction to the technical background of the topic.

As a team of three researchers with a background on formal, algorithmic methods in graph drawing, computational geometry, and information visualization, we have worked ourselves on many external labeling problems, both from theoretical and practical perspectives. After years of research experience it turned out that there is a small set of algorithm design techniques, which can be used to solve a large number of external labeling problems. Thus, one goal of this book is to summarize and explain these techniques to readers with different backgrounds in computer science and related disciplines.

Moreover, we observed that there is a multitude of labeling models with various important parameters, but no commonly used taxonomy guiding experts and novices alike through the existing state of the art. This is due not least because external labeling is studied in many different fields such as algorithm design, information visualization, computer graphics, or virtual/augmented reality, all with their own approaches to the respective problems—from the mathematical curiosity of basic research to the practical needs of creating readable visualizations. A second goal of the book is thus to unify the diverse labeling models and provide a common taxonomy, which facilitates classifying new research results.

A third part of the book covers the existing state of the art in a well-structured way, both in a compact tabular form—where each method is described according to a set of important parameters—as well as in a more detailed description of the respective results. Finally, we pro-

vide a collection of ten research challenges in external labeling to be seen as opportunities for interdisciplinary research collaborations in the coming years.

We hope you enjoy reading this book and find it useful for your own work.

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This book is the result of several years of research experience on external labeling. That said, we deem it important to thank several colleagues and co-authors with whom we have closely collaborated over the years. In close relation to this book, we would also like to thank Denis Kalkofen for fruitful discussions and for exchanging useful ideas with us. The contribution of all reviewers of this book (both named and anonymous) should also be acknowledged, since their insightful comments and suggestions helped in significantly improving both the content and the presentation of this book. Last, but not least, special thanks go to editors Niklas Elmqvist and David Ebert, who invited us to extend a preliminary version of this book into a contribution to the *Synthesis Lectures on Visualization* series, and to Diane Cerra and her team at Morgan & Claypool, who provided us with useful support and helped us accomplish this project.

Michael A. Bekos, Benjamin Niedermann, and Martin Nöllenburg
June 2021

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