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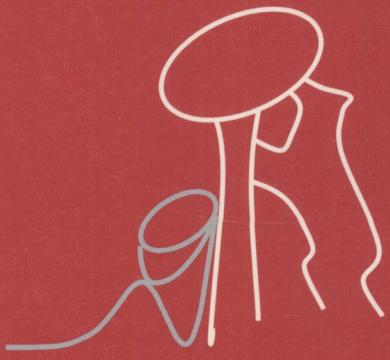
LNCS 3646

Advances in Intelligent Data Analysis VI

6th International Symposium on
Intelligent Data Analysis, IDA 2005
Madrid, Spain, September 2005, Proceedings



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6th International Symposium on
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Madrid, Spain, September 8-10, 2005
Proceedings

Springer

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Library of Congress Control Number: 2005931595

CR Subject Classification (1998): H.3, I.2, G.3, I.5.1, I.4.5, J.2, J.1, J.3

ISSN 0302-9743
ISBN-10 3-540-28795-7 Springer Berlin Heidelberg New York
ISBN-13 978-3-540-28795-7 Springer Berlin Heidelberg New York

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 11552253 06/3142 5 4 3 2 1 0

Lecture Notes in Computer Science 3646

Commenced Publication in 1973
Founding and Former Series Editors:
Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

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Preface

One of the superb characteristics of intelligent data analysis (IDA) is that it is an interdisciplinary field in which researchers and practitioners from a number of areas are involved in a typical project. This also creates a challenge in which the success of a team depends on the participation of users and domain experts who need to interact with researchers and developers of any IDA system. All this is usually reflected in successful projects and of course in the papers that were evaluated by this year's Program Committee from which the final program has been developed.

In our call for papers, we solicited papers on (i) applications and tools, (ii) theory and general principles, and (iii) algorithms and techniques. We received a total of 184 papers, reviewing these was a major challenge. Each paper was assigned to three reviewers. In the end 46 papers were accepted, all of which were included in the proceedings and presented at the conference.

This year's papers reflect the results of applied and theoretical research from a number of disciplines all of which are related to the field of intelligent data analysis. To have the best combination of theoretical and applied research and also provide the best focus, we divided this year's IDA program into tutorials, invited talks, panel discussions and technical sessions.

We managed to organize two excellent tutorials on the first day by Luc De Raedt and Kristian Kersting, entitled *Probabilistic Inductive Logic Programming*, and by Bruno Apolloni, Dario Malchiodi and Sabrina Gaito, entitled *Statistical Bases of Machine Learning*. Our invited speakers were Prof. Ivan Bratko from the Jozef Stefan Institute in Slovenia, and Prof. Alex Freitas from the University of Kent.

We wish to express our sincere thanks to many people who worked hard for the IDA conference to happen in Madrid. Special thanks to tutorial, publicity, local organization, and panel chairs who were in charge of a large portion of our responsibilities. We would also like to thank Xiaohui Liu and Michael Berthold who worked as advisors to this conference, and the members of the Local Organizing Committee for their hard work. Finally, we are grateful to the members of our Program Committee; without their help it would have been impossible to put together such a valuable program.

September 2005

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Probabilistic Latent Clustering of Device Usage

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Abstract. We investigate an application of Probabilistic Latent Semantics to the problem of device usage analysis in an infrastructure in which multiple users have access to a shared pool of devices delivering different kinds of service and service levels. Each invocation of a service by a user, called a job, is assumed to be logged simply as a co-occurrence of the identifier of the user and that of the device used. The data is best modelled by assuming that multiple latent variables (instead of a single one as in traditional PLSA) satisfying different types of constraints explain the observed variables of a job. We discuss the application of our model to the printing infrastructure in an office environment.

1 Introduction

It is nowadays common that printing devices in an office or a workplace be accessed through the local network instead of being assigned and directly connected to individual desktops. As a result, a large amount of information can easily be collected about the actual use of the whole printing infrastructure, rather than individual devices. To be useful, this data needs to be analysed and presented in a synthetic way to the administrators of the infrastructure. We are interested here in analysing the correlation between users and devices in the data, ie. how the printing potential of users translates into actual use of the devices. We assume here that users are not strongly constrained in their use, the extreme case being when any user is allowed to print anything on any device in the infrastructure. The expected outcome of such an analysis may be diverse. For example, the administrator could discover communities of device usage, corresponding to different physical or virtual locations of the users at the time of the jobs, and, from these, form hypotheses on the actual behaviour of the users, both in the case of normal functioning of the infrastructure and in case of exceptions (device down or not working properly). This in turn could lead to more refined decisions as to the organisation of the infrastructure and to the instructions given to its users. It could also help work around failures of devices inside the infrastructure, by redirecting a job sent to a failing device toward a working one chosen in accordance with the community to which the job belongs.

A study on inhabitant-device interactions [6] shows that the recorded device usage can be mined to discover significant patterns, which in turn could be used to automate device interactions. To the authors knowledge, generic user-device interaction analysis in the presence of devices delivering possibly multiple services or levels of service has not been studied extensively.

A.F. Famili et al. (Eds.): IDA 2005, LNCS 3646, pp. 1–11, 2005.

Problem statement. Our overall goal is to analyse usage data in an infrastructure consisting of a set of independent devices offering services of different or identical classes, and operated by a set of independent users. An interaction between a user and a device is called a job. The usage data consists of a log of these jobs over a given period of time. More precisely, we make the following assumptions.

- Let N_U, N_D, N_K denote the number of, respectively, users, devices and service classes, assumed invariable over the analysed period. Each user, resp. device, resp. service class, can therefore be identified by a number $u \in \{1, \ldots, N_U\}$, resp. $d \in \{1, \ldots, N_D\}$, resp. $k \in \{1, \ldots, N_K\}$. Each user, device, service class also has a print name, for display and reference purpose.
- Each device offers services of one or more classes. This is captured in a boolean matrix f of dimension $N_K \times N_D$ where f_{kd} is 1 if device d offers the service class k and 0 otherwise. This matrix is assumed static over the analysed period.
- All the jobs are recorded over the analysed period. Let N be the number of recorded jobs. Each job can therefore be identified by an index $i \in \{1, \ldots, N\}$. Each job i contributes exactly one entry in the log, consisting of the pair (u_i, d_i) identifying the user and device involved in that job. Thus the data is entirely defined by the matrix n of dimension $N_U \times N_D$ where n_{ud} is the number of jobs by user u on device d.

A printing infrastructure in an office is a typical example where our method applies. In that case, a service class could be a particular type of printing. For simplification purpose, in the examples, we consider only two service classes: black&white ($k = 1$) and colour ($k = 2$). Note that a colour printer can always also perform black&white jobs, meaning that if $f_{2d} = 1$, then $f_{1d} = 1$.

Outline of the method. The purpose of our analysis is essentially to discover clusters in the usage data. Since the observed data correspond to co-occurrences of discrete variables, we have chosen an aspect model, which is an instance of latent class models [1], nowadays often referred to as Probabilistic Latent Semantics Analysis (PLSA) [5]. This model is particularly relevant here as its basic assumption has a straightforward interpretation in our context. Indeed, the PLSA assumption is that the data can be generated according to a process that first selects a (latent) cluster, then a user and a device, in such a way that, conditionally to the cluster, the choices of user and device are independent. There is a natural interpretation of such clusters as communities of usage which are associated to physical or virtual locations within the infrastructure. The PLSA assumption means that at a given location, users tend to choose devices in the same way, which is quite reasonable. For example, in an office infrastructure comprising multiple floors, each floor can correspond to a community, whose users share the same perception of the infrastructure and tend to choose printers in a similar fashion. PLSA clustering therefore offers a powerful tool to discover such communities of usage.

However, another important determining factor for the choice of device is the nature of the job to be performed. This information may not be directly available