Business Processes, Dynamic Contexts, Learning

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INTRODUCTION

In this article we relate machine learning methods to business processes. In business are quite many unstructured data that contain hidden information. Business is concerned not only with internal decisions in a closed world. It is rather confronted with a rapidly changing context. That means we deal with an open world.

Dynamic processes and workflows can be changed before or during the execution by a human. This does not allow a precise requirement analysis.

Such changes may happen for different reasons, mainly caused by unpredicted external events, e.g.:

- External changes
- New information during the execution
- The execution shows that the goals cannot be achieved in the intended way.

All these topics give rise to learning because they are not explicitly given but rather hidden in some data. An example is payment behavior analysis. It deals with a certain customer who is partially unknown to us and we want to predict how the customer behaves in the future. However, we have quite a number of data about this customer which contain knowledge in a hidden form. The purpose of learning is to make this knowledge explicit in such a way that we can make decisions about who to treat this customer in the future. Such decisions are based on the insight in customer's behavior and can be regarded as a classification problem. Such examples are discussed below.

A difficulty is that even the structure of the processes is mostly partially unknown and is regarded as stochastic. The only accessible knowledge is observations about the processes executed so far and about the external world. To formulate them is an essential goal for further planning. This leads to the area of stochastic learning. The reader is assumed to be familiar with general business processes and some general (incomplete) view on machine learning but want to get a comprehensive overview.

In the remaining sections we proceed as follows:

- Concepts and terminology of general processes and planning.
- Businesses and machine learning.
- A structural overview of machine learning techniques and methods.
- Major examples of business activities and their relations to machine learning.

It is not intended that the reader learns business or machine learning. Therefore we do not provide detailed definitions of concepts and methods. The idea is that business people get an overview of machine learning so that they can choose a method for their application. Then they can go deeper into the method by investigating the literature.

PROCESSES

Processes, Plans, and Actions

The difference between processes and plans is that a process describes what happens and a plan says what could happen. In a sense, processes are realizations of plans. In processes as well as in

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plans one uses actions for the description. Actions are in their general form mappings:

states → states.

States are described by description elements. In a simple way these are attributes and their values. Actions have preconditions that determine when their executions are allowed. Such allowed actions are arranged in a so-called plan graph with the elements

(state t_1, action a, state t_2).

A plan p is represented as a totally ordered sub graph of the plan graph, i.e. it is a path in the plan graph:

$state_1 \rightarrow state_2 \rightarrow \cdots \rightarrow state_n$

A process models describe sets of processes. Formally one defines them as partially ordered sets actions that may contain variables.

A planning problem is a pair initial state and goal state. A solution S to a planning problem is a plan p where $state_1$ is the initial state and $state_n$ is the goal state. In many situations in business the problem cannot be stated in such a simple way. The two major reasons for this are:

1. Some knowledge is missing.
2. The context is changing that requires re-planning and interference of planning and execution.

If the needed knowledge is not explicitly available one has no other method than to obtain it by machine learning methods from the knowledge hidden in the data.

Intensive research on business runs under the name process mining. It is performed by an IEEE task force group that produces the "Process Mining Manifesto," see (Aarts 2011).

Stochastic Processes

Even if processes are deterministic they may look stochastic from the outside because their structure is unknown. A Markov process has an additional independence assumption by acquiring that the outcome at time t is independent of all events prior to t-1:

$$Prob(X_t = s_j \mid X_{t-1} \wedge X_{t-2} \wedge \ldots \wedge X_0) = Prob(X_t = s_j).$$

Often, the probability distribution is at most partially known. Such situations are considered in the area of Markov process (HMM).

One distinguishes between stationary and non-stationary processes. The first ones have the same statistical characteristics regardless of the time shifts along the axis. That means the parameters of probability model of the process are time-invariant.

A random process is said to be non-stationary if its distributions or statistics vary with time.

Process Adaptation

Often in a certain situation a process P seems to be a useful start. This process may have good aspects but may not be totally convincing. For improving the process one can take this process as an initial approach and improve it by adaptation. Adaptation is applied to the individual actions of the process P. Adaptation occurs quite frequently because one often does not create a plan from scratch but rather modifies a previous one. It is not done in on step but requires several ones.

Adaptations are mappings from plans to plans and are usually defined by rules. The preconditions of the rules state when a certain adaptation is possible. Such a rule is of the form

$\phi_1 \wedge \phi_2 \ldots \wedge \phi_n \Rightarrow$ Action.