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Approach for predicting production scenarios focused on cross impact analysis

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Abstract

One of the most consistent challenges in business is anticipating what the future holds and what impact it may have on current production systems. The scenario technique is a well-established method for developing and forecasting multiple future development paths for companies. However, this method is mostly employed to develop and to support strategic long-term decisions. The core idea of the approach introduced in this paper is to convey the future impact of today's decisions on production systems to employees involved in production planning processes. With the help of immersive visualization, performed in virtual reality (VR) systems, planning participants can perceive how the factory must adapt to fit future demands.

In this paper, the focus is on the fourth phase of the scenario technique – so called scenario development – and, in particular, the cross impact analysis. With this methodology, the interrelations, or cross impacts of the different basic elements are determined. The cross impact analysis results serve as a basis for the development of a standardized tool that can be used to create probable production scenarios out of given production systems. This standardized tool will facilitate the usage of the scenario technique for factory planning projects, as it focuses the immense diversity of future uncertainties companies are faced with on the factory level.

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1. Introduction

Companies set their long term strategy based on their business' vision and the company's size. The strategy determines the future business orientation of the company and all long-term business objectives as well as defining concrete measures to ensure the company is moving in the right direction. The decision about these objectives is set at the strategic management level from the leadership. Conventionally, the strategy of small and medium-sized enterprises is for a period of anywhere between three to five years. For larger enterprises, a long-term strategy can extend out as many as eight or ten years [1]. The necessary tools and methods for making and supporting future predictions are developed in the field of future sciences. However, due to increasingly shorter product life cycles and shorter innovation times for technologies, as well as constantly changing customer requirements for products, companies are forced to revise their strategies in shorter time intervals [2]. In order to use methods from the area of future sciences within a reduced amount of time and without losing any accuracy in the outcome, employees working at the operational level, such as machine operators, assembly line workers, shop floor supervisors, and other employees directly involved with manufacturing must be part of the decision making process. This cooperative decision making process can be difficult due to the inequality of information held between employees in senior leadership positions and employees at the operational level. Senior leaders must ensure that high-level strategic information is provided in basic, general terms that is fully understood and comprehended by everyone involved. At the same time, participants from the operational level must ensure that the information provided is not too detailed such that it may detract from the general purpose of building a strategic plan [3]. Most importantly the

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information must remain focused on the production system and not on information that does not have a direct impact on the production system. This forms the basis for the integration of all relevant persons from various fields and disciplines in a company that are needed for the establishment and communication about future prospects.

This paper highlights the reasons why the scenario technique is relevant for our subsequent approach. An abstracted taxonomy compares different forecasting methods based on characteristics that describe the information source and handling of information. These characteristics are necessary for the approach for shortening the acquisition of information and for facilitating communication between the involved participants. Based on the chosen characteristics, the scenario technique can be seen as a connecting link between the different forecasting methods and integrates them into one. The approach presented in this paper is developed so that the scenario technique can be applied on the operational level through a generalization of information and individual process steps such as the cross impact analysis. Generic results are therefore achieved and will serve as input for the prediction of future scenarios for specific factory planning projects. The way to develop these specific scenarios is sketched and introduced at theoretic level.

2. Forecasting methods to predict the future of a company

The core idea of the approach introduced in this paper is to convey the future impact of today's decisions on production systems to employees involved in production planning processes. With the help of immersive visualization, performed in virtual reality (VR) systems, planning participants can perceive how the factory must adapt to fit future demands. Analysis of proposed planning solutions should be performed in order to assess the factories ability to master estimated future predictions at shop floor level. Therefore a lean, visualizable, and fast forecasting method must be selected to design multiple visions of future shop floor layouts (following called Production Scenarios) according to different future perspectives.

2.1. Forecasting methods of future studies for developing future perspectives

The key to unlocking a company's full potential is contingent on management's ability to accurately predict the future and implement strategy which takes full advantage of the firm's resources. Therefore, one of the most consistent challenges in business management and organization is how the future develops and what impact this has on current factories and production systems. Different forecasting methods of future studies can be used to predict how the future may evolve, derive strategies, and provide recommendations for actions. Following, some of the characteristic forecasting methods are presented briefly.

The cross impact analysis enables a holistic view of possible future developments. Possible dependencies, interactions, and relations can be considered within this forecasting method [4]. The implicit and explicit knowledge of experts forms the basis of expert interviews. The survey may not follow a certain structure. The Delphi method, similar to expert interviews, gathers different expert judgments by using anonymous structured group interviews. Any future projection is independent and possible interactions are not considered [5]. Extrapolating the trend line is a statistical method. Thereby already existing data of a time series is mathematically extrapolated into the future. Mind mapping is a creative and participatory process that allows to create future projections by pursuing a logical chain of events.

The scenario technique is a well-established method for developing and forecasting multiple future development paths for companies on a strategic management level. It generates different future projections by systematically considering different influential factors and disturbance events. The result is an amount of equally valid possible future developments that are consistent in their explanatory power.

2.2. Classification of forecasting methods based on information source and information handling

There are different taxonomies to classify the introduced forecasting methods based on basic characteristics [[6], [7]]. Fig. 1 shows a short taxonomy abstract for common future forecasting methods based on such characteristics. The most relevant characteristics for the approach in this paper are the clear allocation of information types (to speed up and facilitate information gathering) and the ability to communicate information among multiple planning participants (to achieve cooperative assessment).

First, methods can be structured by characteristics such as quantitative information (based on data), or qualitative (based on expert information) [6]. This is important for the formation of the initial situation from which the development of different future perspectives can begin. Because the time required to develop potential future perspectives needs to be reduced (e.g. due to shortened product life cycles), the time needed to provide and retrieve information can be directly linked to the information source. The origin of information retrieval, data-based or expert-based, provides conclusions about the duration of information provision.

Secondly, the characteristic in regard to the handling of information can be broken down into a process consisting of four steps: identifying the information, providing the information, assessing the information, and communicating the information. The identification of information deals with recognizing, processing, and setting information needs. Providing information handles the search of the relevant information's origin. This includes, for example, the distribution of responsibilities to gather information, structure the information, and cluster the information based on its origin. The assessment of information evaluates the situation and environment in which the information was collected. In addition, the information is reduced to a manageable size and processed according to the general objective. Last, the communication of information deals with the distribution of information through different communication channels [7]. These information activities are important for our approach. In particular the last phase (communicating the information) is of