

Strengths and Weaknesses of some popular Technology Forecasting techniques

Analysis of some of the techniques used for technology forecasting (TF) revealed points in favor and against using a particular technique. The techniques were chosen based on the number of publications citing them on Google Scholar (<http://scholar.google.com>).

1 Introduction

This white paper presents part of the work done for task 2.5 (Study of strengths, weaknesses and integrability of the TF methods) of the FORMAT project. The study of the implicit strengths and weaknesses of TF methods and their integrability with each other demands a closer inspection of some of the techniques included in the report by M. Slupinski [1]. Slupinski had tabulated TF methods based on their popularity in Google Scholar. For the sake of study for this white paper, the top 3 most popular techniques were chosen as shown in Table 1.

Table 1 shows the categories of TF techniques with the 3 most popular techniques, based on Google Scholar searches. The values in brackets indicates the number of publications

Causal Model		Phenomenological		Intuitive	Monitoring & Mapping	
Artificial Networking (40000)	Neural	Forecasting by analogy (14000)		Delphi (25900)	Environmental monitoring (23200)	
Multi criteria (11200)	analysis	Simple (10300)	regression	Focus groups (18400)	Stages of development (correlation) (16000)	
Systems (6920)	perspective	Statistic (10100)	modeling	Science fiction (14200)	SWOT	forecasting (12700)

2 Analysis

The techniques listed in Table 1 have been analyzed for strengths and weaknesses. The techniques have been listed below this with a summary of the method along with a gist of the strengths and weaknesses.

2.1. Artificial Neural Networking

Category

Causal Model

Summary

Artificial Neural Networks (ANN) derive their inspiration from neural networks in nature [2]. The forecasting usually involves a phase of training where the network is subjected to a sample of data and then extrapolated to the unseen part, which may pertain to the future. When the variables are known a priori, the approach is called parametric and where the network starts with only data, the approach is called non-parametric [3]. ANN can be used in areas like finance, business, electric load forecasting and airline passenger traffic.

Strengths

The ANN system learns from input data and even though the individual nodes may be inefficient and slow, the overall system is quick and efficient in delivering forecasts. The networks work very well when the time series data is non-linear, dynamic, complex and the inter relationship between the variables is unknown or unclear.

Weaknesses

Integration into system level long-term prediction needs to be done [4]. This method needs the users to have experience and time to get reliable results and may be complicated for simple systems where there is considerable understanding of the dependent parameters.

2.2. Multi criteria analysis

Category

Causal model

Summary

FOR LEARN project [5] describes this method which aims to compare various solutions or paths forward in a technology to a list of criteria, while using weighted averages to evaluate the actions or solutions available. The method is used as a decision making tool in the strategy phase of a project. Particular attention has to be paid to the criteria chosen as was done for the evaluation of alternatives to mobile phones in Işıklar et al [6].

Strengths

This method is largely a survey based method and allows for changes even after the initial survey is done. The initial forecasts can be course corrected after new data or trends start emerging. Since the choices and weightages are numeric, the decisions and the justification for decisions is straight forward.

Weaknesses

Dependencies, synergies between the listed actions may complicate the model. This method is meant for simple models.

2.3. Systems Perspective

Category

Causal model

Summary

This method largely focuses on considering the “bigger picture” or whole of the system, the parts of the system and the relationship between them [7]. In addition to the system, the neighboring “universe” where the systems exert influence need to be identified. The ability to understand complexity and the need to be multidisciplinary are critical to this method [8]. The method has application in varied fields like video games, psychology, hospital systems. There is no system that the method is particularly suited for.

Strengths

Rapid change, “wicked problem”, high complexity problems can be handled well.

Weakness

Slow start, slow process and slow decision making are part and parcel of the systems perspective. Ability to think about the system level does not lead to action and hence action has to be separated from system thinking.

2.4. Forecasting by Analogy

Category

Phenomenological model

Summary

“This project is as big as the Manhattan Project” is one of the analogies that can be used to convey what the method is all about. The scale or time period of an event in the past can be projected onto the situation at hand [9]. A case based forecasting system (CBFS) was developed by automating the process of identifying similar cases from history to generate forecasts about the future [10]. The CBFS method was used in project management to generate similar projects that have been executed successfully in the past.

Strengths

Current and historic examples can be compared in a systematic way and this approach can be extended to new products as well.

Weakness

People are unpredictable and similar situation in the past does not imply similar results

2.5. Simple Regression & Statistic Modeling

Category

Phenomenological model

Summary

Simple regression, statistic modeling and data mining are all clubbed under one subheading because of similarities in the methods [11–13]. In these mathematical methods, the main assumption is that the data needed for the forecast is available [14]. The data is used to build models that can be used to extrapolate and generate predictions. The applications for these methods are numerous and apply mainly to areas where there is extensive data and where the application of mathematical recipes yields results. Some example applications are genetics, computational fluid dynamics.

Strengths

Empirical models based purely on data mining or historic data can include variables that the expert overlooked

Weakness

The data based models do not explain the underlying truth of why the technology is progressing in a particular direction.

2.6. Delphi & Focus groups

Category

Intuitive model

Summary

One of the most popular methods for knowledge extraction from experts and other important stakeholder has been the Delphi method. This method involves questioning a panel of experts and eliciting forecasts on specific technology with minimal face to face interactions. A moderator collates the data and conducts multiple rounds of interviews where the panelists are allowed to withdraw, change or justify their predictions. At the end of the rounds a report is generated with all the predictions, objections and changes noted [15–18]. Delphi started out as a forecasting method, but has many variations now in fields like management, planning, education apart from forecasting.

Strengths

Incorporates all the advantages of a committee (“2 heads are better than one” and taking into account a number of factors that affect the forecast) and allows for correcting forecasts without the need for a consensus. There is no room for arguments and hence the forecasting sessions are focused on technology forecasting.

Weakness

There is room for introducing a bias by way of the questions from the moderator. If all the experts involved are misinformed, then the forecasts also tend to be erroneous and correction is difficult. Collating data from experts and preparing for the different rounds of Delphi is time consuming and expensive. Getting the experts’ time can be expensive as well.

2.7. Science Fiction

Category

Intuitive model

Summary

Science fiction is popular and is often used to look at what might potentially happen in the future with warnings about technological oppression and future directions [19], [20]. The technique involves looking for major leaps in technology in works of science fiction. Application areas include nanotechnology, medicine, computers [21–23].

Strengths

Science fiction shapes the science of the future and the trends of technology influence science fiction. As a technique of forecasting, this tool is easy to understand.

Weakness

The forecasts may be vague and cannot be used for policy changes or planning.

2.8. Environmental Monitoring

Category

Monitoring & Mapping

Summary

The method of scanning a technology for early indicators of a breakthrough is called environment monitoring [24]. The method is described to be very rigorous and involves collection, screening, evaluating and setting a threshold for a particular technology. The method involves full time dedicated personnel identifying information in the above mentioned stages of environmental monitoring. Some of the sources of data for monitoring are: a) information collection services such as Google Scholar or Google Alerts, b) essays by experts, c) literature review, d) key person and conference tracking, Environmental monitoring or scanning has been used in areas like strategic planning for corporations, education planning [25–27].

Strengths

Technology “Breakthroughs” bring about the most change and usually precursors or significant events. The detection of these precursors or events can lead the correct prediction of “breakthroughs”.

Weakness

Requires dedicated personnel monitoring technological factors rigorously

2.9. Stages of development (correlation)

Category

Monitoring & Mapping

Summary

Stages of development is very similar to environmental scanning in terms of tracking early information, however the information from the development of an innovation [28]. The example used is that of a feature of a car which moves from experimental to the luxury segment and then to the mass market. Thus detecting this lead-lag correlation, one can predict the features for future cars in the mass market segment. Examples of application of this method has been cited in nanotechnology and human interface devices [29].

Strengths

Several features of a technology follow specific patterns in the stages of development and therefore can be a useful indicator of an upcoming technological feature.

Weakness

The forecaster should be well aware of the technology and the positive trends to latch onto and beware of false trends.

2.10. Strengths-Weaknesses-Opportunities-Threats (SWOT) forecasting

Category

Monitoring & Mapping

Summary

SWOT analysis is primarily used to analyze the current situation of a technology, but the opportunities and threats can be used to assess the future of a technology [30]. Application of this method has been in various field like energy, telescopic drilling [31], [32].

Strengths

Non technical nature of the tool increases ease of use along with being highly flexible

Weakness

Lack of prioritization and possible vagueness in the usage of words

3 Conclusions

The TF tools were chosen based on the number of research publications on Google Scholar and were analyzed for strengths and weaknesses. The overall observation on these tools is that there is an abundance of TF tools for a forecaster to choose from, although there is no one perfect tool which can serve as a one-stop destination. Although Slupinsky [1] has categorized into causal, phenomenological, intuitive and monitoring and mapping, the TF tools need to be grouped into the stage of the TF or phase of innovation that the product or process is in. The rationale behind choosing the most popular TF techniques is so as to find the most literature and hence learn from experience of others in the fields for the benefit of the FORMAT project.

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