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Technology life cycle analysis method based on patent documents

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ABSTRACT

To estimate the future development of one technology and make decisions whether to invest in it or not, one needs to know the current stage of its technology life cycle (TLC). The dominant approach to analysing TLC uses the S-curve to observe patent applications over time. But using the patent application counts alone to represent the development of technology oversimplifies the situation. In this paper, we build a model to calculate the TLC for an object technology based on multiple patent-related indicators. The model includes the following steps: first, we focus on devising and assessing patent-based TLC indicators. Then we choose some technologies (training technologies) with identified life cycle stages, and finally compare the indicator features in training technologies with the indicator values in an object technology (test technology) using a nearest neighbour classifier, which is widely used in pattern recognition to measure the technology life cycle stage of the object technology. Such study can be used in management practice to enable technology observers to determine the current life cycle stage of a particular technology of interest and make their R&D strategy accordingly.

1. Introduction

The rapidly changing economic environment and increasingly fierce competition require companies to be innovative, both in their products and marketing strategies, if they are to flourish. A successful product must balance three components: technology, marketing, and user experience [1]. Technology plays a key role among these three components [2]. Before the product strategy is formulated, a technology strategy must be developed to provide competitive products, materials, processes, or system technologies [3]. The first step for devising a technology strategy is to decide if the technology is worth the investment. How will the technology develop in the future? Will the technology flourish in the future or will it decline? To answer these questions, one should know the current life cycle stage of the technology in order to estimate future development trends to make informed decisions on whether to invest in it or not.

Within the Future-oriented Technology Analysis (FTA), technology forecasting traces back to the 1950's [4]. One of its half-dozen or so basic techniques, dating from that time at least, is trend analysis. This includes both historical time series analyses and fitting of growth models to project possible future trends [5]. Most trend projection is "naïve" — i.e., fitting a curve to the historical data under the assumption that whatever forces are collectively driving the trend will continue into the future unabated. It follows that such projection becomes increasingly precarious as the future horizon is extended beyond a few years.

Another important technology forecasting technique [6] is the use of analogies. Herein, one anticipates growth in an emerging technology based on the pattern of growth observed in a somewhat related technology. The stronger that relationship, the more likely the pattern will pertain.

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Another important predecessor approach upon which we draw is the identification of Technology Readiness Levels (TRLs). The U.S. military, especially the Air Force, has made use of this categorization of technology development to help identify current status and future prospects. Nolte et al. [7] overview the 7-level TRL and how to estimate this. The U.S. National Aeronautics and Space Administration (NASA) uses a 9-level version [8]. When a complex technical system incorporates a number of emerging technologies, use of TRLs has proven helpful in designing a viable new system. The key notion is that progress is likely, but precise anticipation of when a given advanced technology will be ready for application is precarious. Such a cautionary notion should be recognized for our approach developed here also.

The concept of the technology life cycle (TLC) was presented by Arthur [9] to measure technological changes. It includes two dimensions — the competitive impact and integration in products or process — and four stages. According to Arthur's definition, the characteristic of the emerging stage is a new technology with low competitive impact and low integration in products or processes. In the growth stage, there are pacing technologies with high competitive impact that have not yet been integrated in new products or processes. In the maturity stage, some pacing technologies turn into key technologies, are integrated into products or processes, and maintain their high competitive impact. As soon as a technology loses its competitive impact, it becomes a base technology. It enters the saturation stage and might be replaced by a new technology. According to this definition, Ernst [10] developed a map to illustrate TLC (Fig. 1).

The dominant approach to analysing TLC with an S-curve is to observe technological performance, either over time or in terms of cumulative R&D expenditures. But using one indicator only to present technological performance would be problematic. A research team from MIT [11] studied the development trends of power transmission technology and aero-engine technology by S-curve modelling. The results showed that the S-curve with a single indicator was not reliable and might lead the research in the wrong direction. They suggested considering multiple indicators to measure technological development and to make business decisions.

Usually, patent application activity is tracked as a TLC indicator for the S-curve analysis [10,12,13]. But using patent application counts alone to represent the development of technology oversimplifies the situation. Accordingly, some multiple indicators are used to measure TLC. Watts and Porter [14] have introduced nine indicators that look at publications of different types during the technology life cycle. Reinhard et al. [15] tested seven indicators related to patents. Table 1 shows the indicators listed in the two papers. These papers studied the indicators that would have different performance based on the changes of technology. Separately, the indicators can serve to measure technological changes. In this paper, we focus on combining multiple indicators to calculate the life cycle stages for an object technology and hope that would help decision makers estimate its future development trends.

2. Methodology

The model that we build to calculate the TLC for an object technology includes the following steps: first, we focus on devising and assessing patent-based TLC indicators, then we choose some technologies (training technologies) with identified life cycle stages, and finally we compare the indicator features in training technologies with the indicator values in an object technology

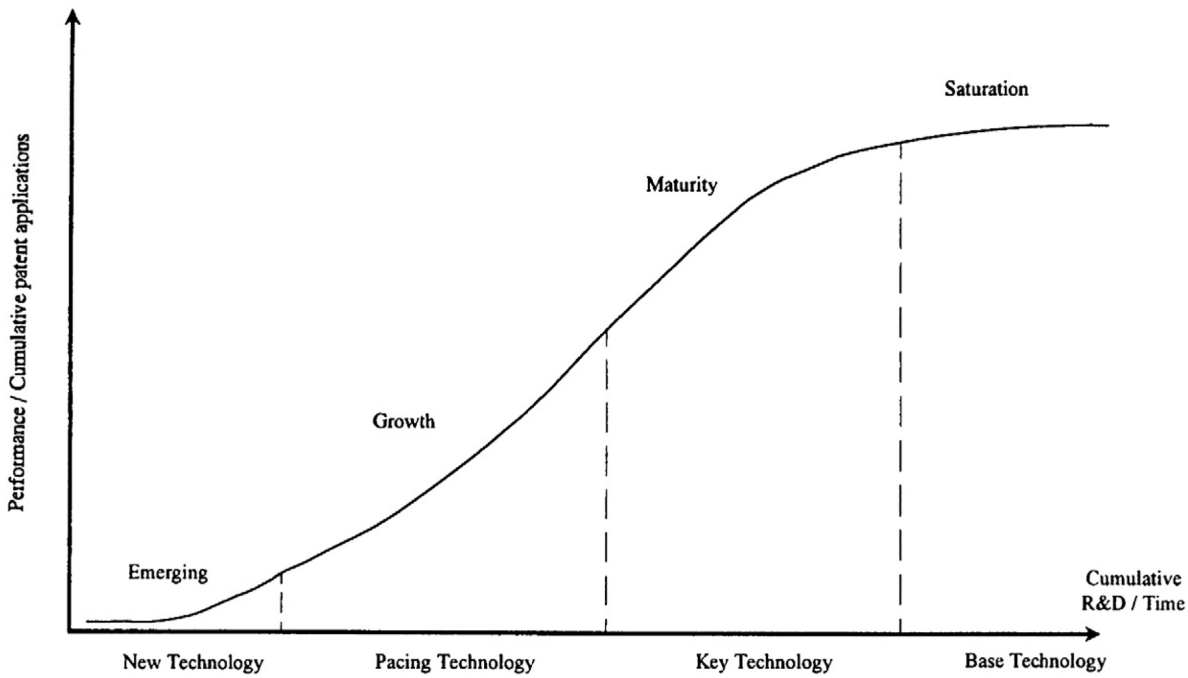

Fig. 1. The S-curve concept of technology life cycle.

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