"A FRAMEWORK AND METHODOLOGY FOR ENHANCING THE BUSINESS IMPACT OF ARTIFICIAL INTELLIGENCE APPLICATIONS"

by

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Abstract

Artificial intelligence (AI) technology is being increasingly used for commercial applications. The past decade has seen many advances in the development of AI theory and tools. However, there is a dearth of research into frameworks and methodologies for identifying strategic applications of AI. AI applications which enhance the competitive advantage of a company are of strategic value to the organization. This paper presents an approach based on "information and value profiling" for choosing strategically important AI applications. AI groups in companies can use this methodology profitably to better align their development efforts with the corporate strategy of the firm.

1. Introduction

This section describes issues in the justification of commercial AI projects and describes the foci and structure of the paper.

1.1 Fundamental Features of AI

According to the Handbook of AI [1] "the realization that the detailed steps of almost all intelligent human activity were unknown marked the beginning of artificial intelligence as a separate part of computer science". A similarity of different AI sub-fields (such as expert systems, natural language understanding and robotics) is that they all profess to study different aspects of intelligent cognitive skills. Such a definition has problems as argued by Beau Sheil. He notes [7] that "about the only thing that 'intelligent' skills obviously have in common is our ignorance about how they are done" and further that "the more we understand a problem, the faster it moves out of the realm of AI". For example, performing the addition of two integers (2 + 2 = 4) can at some level be called the performance of an "intelligent action" which is done by humans, but it is not considered as a subject of study in AI as the process of addition of integers is not "unknown".

A fundamental feature of all cognitive skills is the processing of information. Each problem in AI is ultimately concerned with processing information, regardless of whether they are input in the form of pixels (vision systems) or electrical signals (speech recognition systems) or written text (natural language systems). The kind of information to be processed and the difficulty of the process determines to a large extent whether the activity falls under the domain of AI. The information associated with the addition of two integers is simple and the process of addition is well defined. Thus it is of little interest to AI. In contrast, the information content in the domain of medical diagnosis is complex and the reasoning processes are not equally well defined. Thus it has successfully served as a rich test-bed for AI research [2].

1.2 Business Applications of AI

The justification and management of AI projects has not been easy in many companies. Given the inherent nature of AI tasks ("solving the unknown"), it is difficult to come up *apriori* with precise specifications and a cost-benefit analysis of tangible benefits. The normal processes of "project approval" do not carry over well to the uncertain, exploratory mode of programming and rapid prototyping popular in the development of AI systems. Such development techniques are often essential given the nature of AI tasks and usually generate valuable insights during the process of development. While initial excitement has been relatively easy to generate, AI development teams have experienced problems in obtaining **substained** upper management commitment and resources. A partial solution to this problem has often been advocated in the AI literature: choose less complex and better structured problems which are "doable". An assumption in choosing such a path is that succeeding in solving "doable" problems shall build credibility of AI groups within an organization and win management support and resources for other projects. While tackling "easier problems" is by itself not a bad idea (feasibility of applications is an important issue), it tends to shift the focus away from the ultimate aim of deciding to solve the problem in the context of a firm's operation: does the application have an impact on the firm's competitive advantage? AI applications, even if successful and technically advanced, may fail to impress and win upper management support if they do not yield a competitive advantage to the firm in the long run. An application, if properly identified as having potential for strategic benefit to the firm, shall (with proper communication) be better placed to win substained upper management support and required resources, even if it is technically complex.

1.3 Foci of Paper

Like other technological projects, AI applications typically have several phases such as *identification* (of the application), (project) *feasibility study*, *development* (a process which needs to be managed), *transfer of technology* (to users) and *maintenance* (of installed application). All phases are important and have their own challenges. This paper focuses on the initial phase of project identification.

There has been little prior research in developing frameworks and methodologies for identifying AI applications which potentially have an impact on a firm's profitability

and add to its competitive advantage. Inadequate attention to the strategic impact of applications can lead to the selection of projects of low strategic value.

This paper presents an approach of "information and value profiling" based on Porter's value chain model [6] of a firm's activities to develop a methodology for identifying strategic applications of AI. By using the framework outlined in this paper, AI development groups in commercial firms will have a better understanding of the alignment of AI projects with corporate strategy. This will help them to identify the set of strategically important AI applications to be explored further for feasibility and development.

1.4 Structure of Paper

There are three additional sections in this paper. The next section reviews some relevant prior research. Section three describes the "information and value profiling" approach to the identification of strategic AI applications. Section four concludes the paper with an assessment of the implications of the ideas presented in the paper.

2 Prior Research

This section introduces some relevant prior research. The "value chain" framework of Porter [6] is emphasized.

2.1 Porter's "Value Chain" Framework

In 1985 [6], M. Porter outlined the *value chain* concept for analyzing the competitive advantage of a firm. This concept divides a company's activities into the set of technologically and economically distinct activities that it performs to do business. Each of these activities are termed as "*value activities*". These value activities can be divided into nine generic categories (see Figure 1). Primary activities are those involved in the physical creation of the product, its marketing and delivery to buyers, and its support and servicing after sale. Support activities (shown shaded in Figure 1) provide the inputs and infrastructure that allow the primary activities to take place. Every activity employs purchased inputs, human resources, and a combination of technologies. The actual activities performed within the nine generic categories varies from company to company. *The value a company creates is measured by the amount that buyers are willing to pay for a product or service.* Each value activity makes a contribution to the total value created by the company. A business is profitable if the value it creates exceeds the cost of performing the value activities. A company can gain competitive advantage over its rivals by either performing these activities at a lower cost or in such a way that it leads to differentiation of product and a premium price (more value).

The value chain concept of Porter is a useful and popular framework for analyzing the sources of competitive advantage for a company. Although, the precise nature of different value activities and the structure of the value chains vary from company to company, it does provide a common framework for the analysis of the competitive

advantage of firms. Firms "ideally" adopt a corporate strategy deciding their targeted source of competitive advantage and then work towards it.

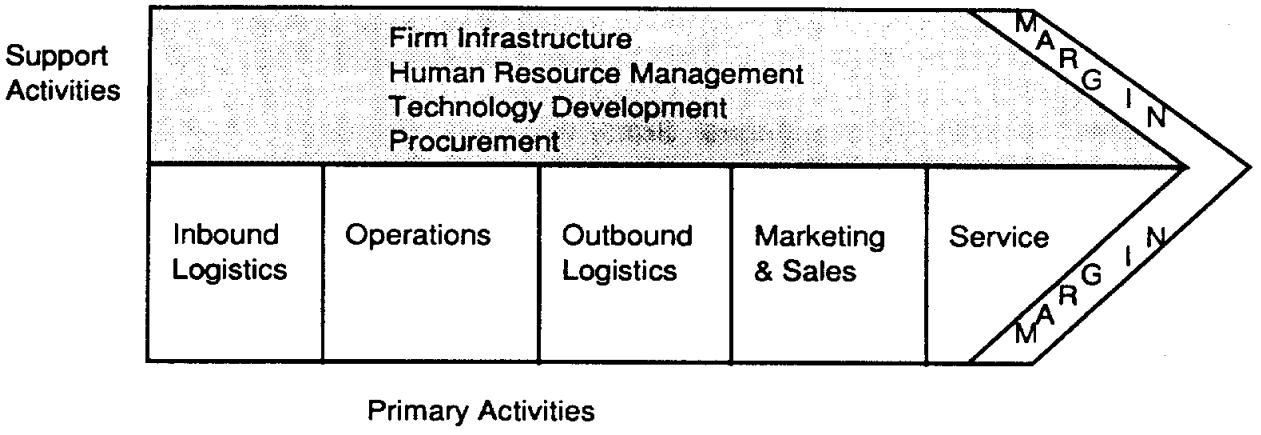

Figure 1: Porter's Value Chain

Porter and Millar [5] have studied the effect of information technology on the value chain and concluded that *"information technology is permeating the value chain at every point, transforming the way value activities are performed and the nature of the linkages between them."*. They have postulated that every value activity has both a physical component and an information processing component. The physical component includes all physical tasks necessary to perform the activity and the information component includes *"the steps required to capture, manipulate, and channel the data necessary to perform the activity"*. While they recognize that computer based systems can be used for many different value activities, they do not prescribe any guide-lines for choosing the appropriate information technology for various tasks or for deciding among different tasks.

2.2 Other Related Research

There has been some research on the question of matching task to technology. Luconi, *et. al.*, [3] identified four different components of tasks: *data* (current state of world), *procedures* (or operators), *goal and constraints*, and (problem solving) *strategies*, and then defined four different types of problems depending on the relative dependence on computers/humans for problem solving. Type I problems are "structured" and are solved entirely by computers. Type 4 problems are "unstructured" and are solved by both computers and humans. Type 2 and 3 problems are termed "semi-structured". Expert systems were identified as being appropriate for type 3 problems and were recommended for use when all four components of the task could be automated. The emphasis in their model was on identifying the underlying structure of problems and not on analyzing their strategic benefits.

Sviokla [8] has used the value chain concept for identifying expert system applications. He recommends identifying the *"role of experts and expertise"* in different parts of the value chain and then using a list of "*desirable expert system*

attributes" to determine expert system feasibility. The list of "desirable expert system attributes" consist of many by now familiar recommendations, such as: credible expert exists; task is neither too easy nor too difficult; task is sufficiently narrow and self contained; senior management is supportive and so on. While these issues are relevant for determining the feasibility of expert systems, the issues discussed in this paper are different.

3 Information & Value Profiling

This section describes our proposed methodology of "*information and value profiling*" for identifying strategic applications of AI. The approach described below is a general one and can be adapted for different kinds of technologies. We develop it here for the case of AI.

General Framework & Methodology

We use Porter's value chain to develop our methodology which consists of the following steps:

[1] Draw the value chain of the company and determine high value activities in the value chain.
[2] Determine the information profiles for high value activities.
[3] Draw the information profile of the AI technology(ies) under consideration.
[4] Determine suitability of the AI technology(ies) by comparing the information profiles of value activities (step 3) to that of the AI technology(ies) (step 4). This leads to the selection of a subset of value activities from step 1.
[5] Draw the existing information value profile for the activities of step 4.
[6] Determine the additions to the information value profiles of step 5 by the use of the AI technology(ies) under consideration.
[7] Select the activity from step 6 that is both a high value activity in the value chain and to which AI technology adds the most value.

We explain each of these steps in more detail below.

Value Chains and High Value Activities

A company's value chain is a system of interdependent activities which are connected by linkages. Linkages exist when the way in which one activity is performed affects the cost or effectiveness of other activities. The value chain of a company can be represented by a directed graph (see Figure 2) in which each node represents a particular activity and links represent dependencies between activities. A company's value chain is part of a larger system called a *value system*, which additionally comprises of the supplier's value chain and the value chains of the distribution channels and the final buyers. Linkages exist between the value chain of the company to the value chains of the supplier and its customers. Figure 2 depicts a simple value system. Different companies have different structures for their value chains and the value system to which they belong.

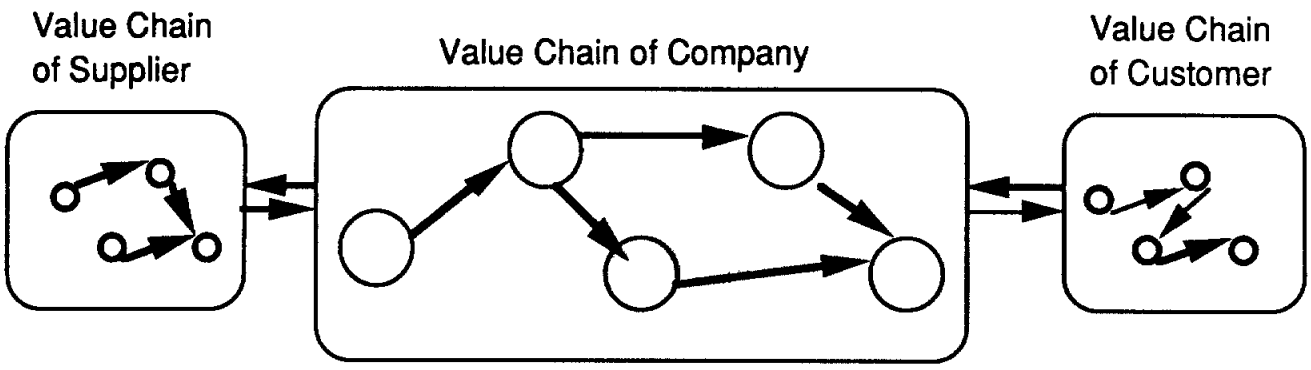

Figure 2: Value Chain of a Company in a Value System

After obtaining the value chain of the company, the sources of competitive advantage to the company in the value chain have to be analyzed. Each value activity generates some value and high value activities have to be recognized. An activity can create value directly (through the processes taking place within that activity) or by influencing the links emnating from it. Careful management of these linkages, i.e., the interactions between different value activities is often a powerful source of competitive advantage because of the difficulty rivals have in perceiving them and in resolving tradeoffs across organizational lines. A company can also create competitive advantage by coordinating or optimizing links to the outside, i.e., to the suppliers and customers.

It is important to recognize high value activities to a company as they form a good first selection of activities for developing AI applications. AI appplications developed for low value activities, even if successful, often go unnoticed by upper management. The suitability of AI technology for high value activities is decided by the following steps.

Information Profiles of Value Activities

This step is concerned with characterizing the information processing in high value activities.

Porter and Millar [4] have used the term "*information intensity*" to describe the cumulative intensity of information in the value chain of a company. However, the term "information intensity" is of little use without precise definitions and measures. Different activities impose different requirements on the processing of information. Attributes of information processing at a particular activity must be analyzed to determine which features are most important. The particular choice of features along which to analyze the task of information processing is domain dependent and can vary from activity to activity within a value chain. For example, consider the following four attributes of information processing in a value activity:

[1] **Volume**: This refers to the volume of the information to be processed in the value activity. The volume of information can be high (e.g., bank transactions) or low (e.g., engineering design).

[2] **Definition**: This refers to the structure of the process for processing the information in the value activity. The process can be well defined (e.g., maintaining the accounts of a bank's transactions) or poorly defined (e.g., medical diagnosis).

[3] **Urgency**: This refers to the temporal urgency of information processing. In real time situations (such as in credit approvals) the urgency is high. In some other transaction processing applications the urgency is relatively low.

[4] **Distribution**: This refers to the geographical distribution of the information,i.e., is it centralized or decentralized or partly both.

It is recommended to focus on the fundamental attributes of information processing and not get bogged down in details. This is because the emphasis is on identifying strategically important applications and communicating the ideas to upper management (who are usually not knowledgeable of finer technical details). Technical details form an essential part of the feasibility study which is done after the initial stage of identification of strategic AI applications. Note that the above list is not a complete list and is not intended to characterize information processing in all value activities. All attributes of information processing may not be equally important and it may be necessary to assign weights to the different characteristics. For simplicity, we assume that all attributes are equally important for describing the information processing.

Consider qualitative ranges for the four termed attribute list mentioned above: **Volume** ranges from *low* to *high*; **Definition** ranges from *good* to *poor*; **Urgency** varies from *low* to *high* and **Distribution** spreads from *centralized* to *decentralized*. To generate the information profile of any value activity, it is necessary to consider each of these four attribute ranges and plot a point or an interval whose value(s) best reflects the information processing requirements of that value activity along that attribute. The information profile for the value activity is then obtained by joining the points on the four axes. Both quantitative and qualitative ranges can be used. Context sensitivity is important while drawing the information profile. For example, a certain amount of information may be high for one person doing a value activity but can be moderate or even low if that value activity is done by groups.

Consider the example of credit approvals. Companies like American Express typically pass each credit request through a statistical credit check. If the request falls within acceptable ranges for the parameters of the test, the request is automatically granted. However, if the request has some anomaly, a service agent has to step in and decide whether to grant the request or not. The information profile for the activity of the agent checking the credit request would look like as shown in Figure 3. The profile shows a high volume of information processing with a high degree of urgency. The definition is moderate to poor as the agent typically uses both rules and subjective analyses in his/her decision. The distribution of information is

somewhere between centralized and decentralized as the agent has to often consult many remote databases.

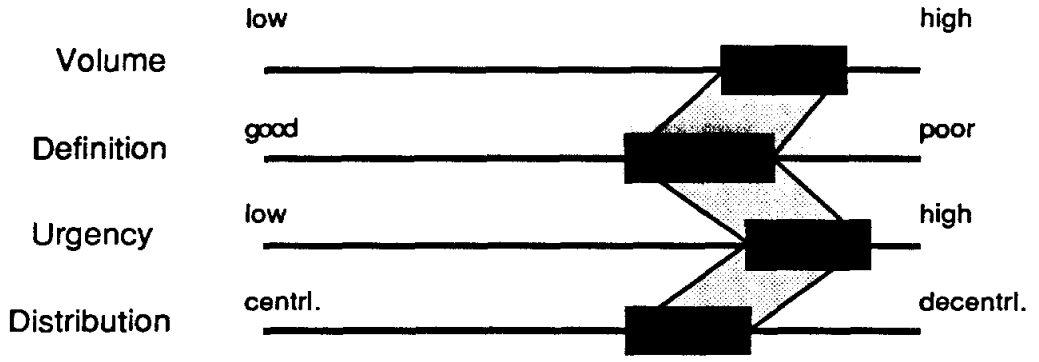

Figure 3: Information Profile for Credit Approval Activity

Information Profiles For AI

The information profile of a particular AI technology identifies the suitability of the technology for processing information as measured along the attributes under consideration. The process of drawing the information profile of an AI technology is similar to that of drawing the information profile of the value activities. A set of attributes has to be chosen and the suitability of the technology has to be plotted along those attributes. To facilitate matching activity to technology, it is helpful to select the same set of attributes (and their corresponding ranges) as in the information profile of the activity for which the technology is being evaluated.

AI is a vast field with many different sub-fields. An information profile can be drawn for each of these sub-fields. Figure 4 depicts the information profile of expert systems. The same four attributes of Volume, Definition, Urgency and Distribution are used for drawing the profile. Expert systems enable fairly high volumes of information to be processed (by automating the reasoning of the expert) and usually deal with problems of moderate to poor definition (for which no efficient algorithms exist). They decentralize information processing (expert knowledge is available in many sites) and help in solving problems faster (by less experienced users).

Matching Value Activity To AI Technology

Having obtained the information profiles of both individual value activities and the particular AI technology under consideration (expert systems in our example), matching activity information processing requirements to technology involves comparing their respective information profiles for the degree of overlap. If the information profiles of the activity and AI technology have a high degree of overlap, then the AI technology is probably suitable for application in that activity and vice versa. The intent of this step is to determine whether the AI technology under consideration can provide the information processing capabilities required by the

value activity. It is essential that the information profile of an activity consider all important features of information processing at that activity.

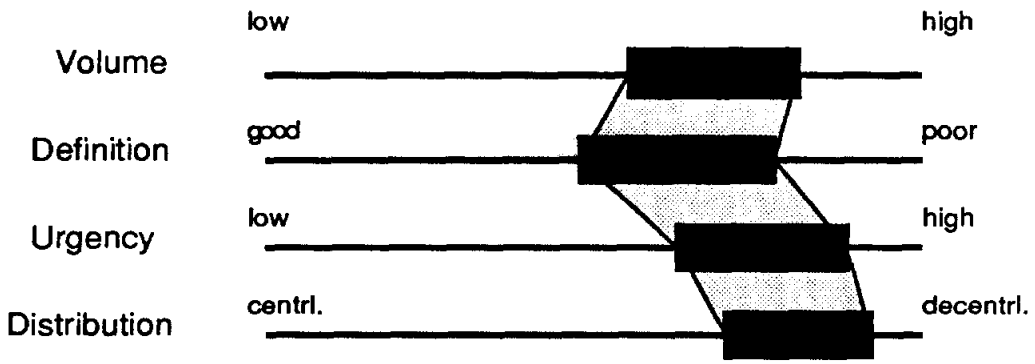

Figure 4: Information Profile for Expert Systems

Looking at figures 3 and 4, it can be observed that there is a high degree of overlap between the two information profiles. Thus it can be concluded that it may be possible to use expert systems for the activity of credit approval. The word "may" is emphasized because identification of compatibility of value activity and technology is a small step in the successful implementation of the technology for that activity.

Existing Information Value Profiles of Activities

The existing information value profile for an activity describes the value created by the current information processing infrastructure at that activity measured along the same attributes as the information profile of that activity. The information processing infrastructure consists of both personnel and various computer based systems. This infrastructure has varying degrees of proficiency in handling the different dimensions of information processing at that activity and in doing so creates degrees of value along each dimension. The created value is based on its information processing proficiency along that dimension and the strategic value of adequate performance on that dimension of the information profile. For example, if processing high volumes of information at a value activity is of high strategic impact and the existing infrastructure is good at doing so, it creates high value along that dimension. This "*value creation*" by the information processing infra-structure can be captured by an "*information value profile*". In an information value profile, the value created by the information processing infra-structure along each attribute of information processing is measured on a scale ranging from low to high.

Figure 5 depicts the existing information value profile (by the line joining empty rectangular boxes) for a hypothetical scenario of credit approval by human agents. It is assumed that the agents are understaffed for the large number of credit approval requests received and have to access information from geographically distributed databases. The value created along the volume and urgency dimensions are moderate as the agents (by assumption) are understaffed. The agents can reason well about the process (the value created along the definition dimension is fairly high), but have

difficulty in accessing and using all remote data (the value created along the distribution dimension is moderate).

Value Added by Proposed Application of AI Technology

The application of the AI technology shall affect one or more aspects of the information processing capabilities at the value activity and in doing so shall change the information value profile of the activity. This step requires that this effect of the AI technology be analyzed and represented by a new information value profile.

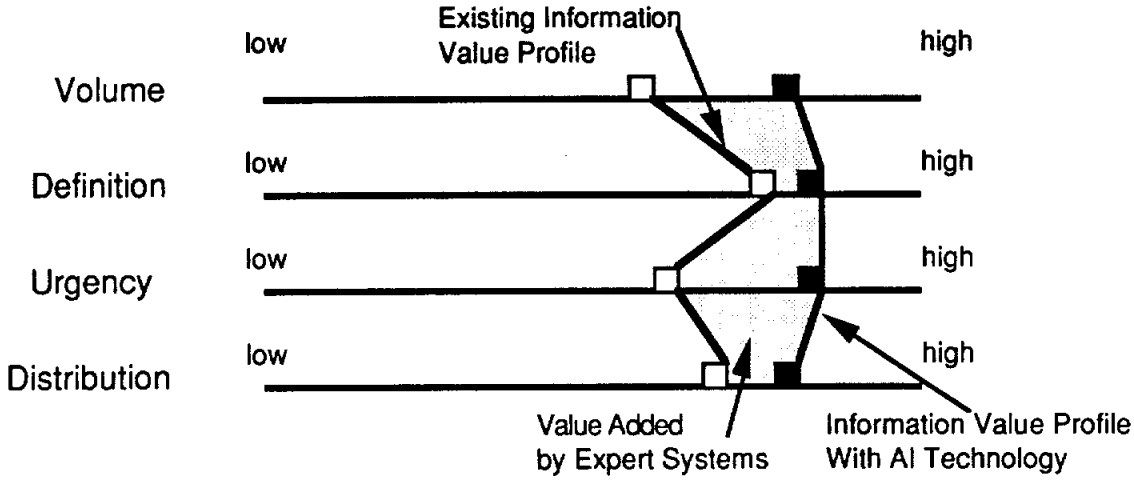

Figure 5: Information Value Profiles

Consider the proposed application of expert systems to the activity of credit approval. The new information value profile for credit approval (with the use of expert systems) is represented by the line joining the black rectangles in figure 5. Use of an expert system would add significant value along the volume, urgency and distribution dimensions as an expert system would enable more requests to be processed in a shorter time and also use more information. The value added along the definition attribute is relatively small as the expert system would not alter the reasoning of the agents, except to perhaps improve the overall consistency of decision making. The extra value added is shown by the shaded region in figure 5.

Aligning AI Development Strategy With Corporate Strategy

The last step in the proposed methodology is to choose an AI application which adds significant value to a high value activity. Step 1 in the proposed methodology identified high value activities and step 4 isolated the high value activities suited to the application of the AI technology under consideration. Step 6 described the value added by the AI application to the activities found suitable in step 4. Step 1 is important as it removes activities of low strategic importance. It is not wise to invest efforts in applying AI to such low value activities, even though AI may add significant value to the information value profiles of these activities. The AI technology under consideration may add significant value in more than one high value

activity. The subset of these high value activities selected for further exploration (feasibility studies) depends on the context of the firms operations and on the level of AI development within the company.

4 Conclusion

This paper has presented a framework for identifying those applications of AI which have a high impact on a firm's competitive advantage. It is important to note that choosing AI applications using this framework does not guarantee the successful implementation of AI as it does not include aspects such as the study of feasibility of the application, the management of the development of the application and its maintenance. Each of these other areas has its own challenges and are equally important for ensuring that AI applications are successful and have a significant impact on a firm's success. The proposed methodology gives guide-lines and a process for choosing the right path for AI application development. It does not tell how to walk down this path and successfully reach its end.

The significance of this research arises from the fact that there has been negligible prior research along these lines. It is hoped that the contents of this paper will give different AI development groups in companies a framework for choosing strategically important AI applications. It is only by understanding the issues mentioned in the paper and clearly communicating to upper management the fit between corporate strategy and AI development strategy, can their continued support and commitment be obtained.

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