

Measuring the Penetration of Intelligent Technologies in Medical Business

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ABSTRACT: The purpose of this paper is to present a survey on the penetration of intelligent techniques in medical industry. Our sample consists of companies specialised in either of the following business fields: (1) medical technology (equipment, apparatuses, instrument, etc.), (2) medical computing (software, computer integrated systems, e-health applications, etc.) (3) medical management (consulting, decision support systems, etc.) and (4) pharmaceuticals. Various issues were examined in this research. First of all, we investigated the familiarity of the actors of medical business with intelligent methodologies and the extent to which intelligent techniques are used in any of the above sectors of medical industry. Of extreme importance was also to learn the attitude of medical entrepreneurs towards intelligent methodologies. For that purpose, respondents were asked about the effectiveness and profitability of intelligent systems compared to less 'intelligent' and conventional techniques. Another issue, also of great interest, was to get an idea of the future perspective of intelligent methodologies in medical industry. Several questions were also addressed here inquiring about the business priorities of medical companies and their tendency towards investing on intelligent techniques. On the focus of our research was to correlate responses to the above questions with several sample variables, such as the size or growth of the company being questioned, the geographic and thematic area of action and the intensity of competition in the market in which the medical company is developed. We believe that our research could reveal some important strategic issues regarding the diffusion of intelligent technologies in medical business.

KEYWORDS: intelligent technologies, medical business, questionnaire survey.

1. INTRODUCTION

The past decade has experienced a great deal of scientific activity on standard intelligent techniques (fuzzy logic, evolutionary computing, machine learning & neural networks) as well as on adaptive and hybrid intelligent systems. Despite the continuously growing number of publications in this area, it is not yet clear whether companies have realised the potential of intelligent techniques in solving real-world problems as well as the new opportunities given on a business level.

In one of the first attempts, CoIL (the **Computational Intelligence and Learning cluster**¹) conducted a survey to gain a picture of the current state of the art and future expectations of intelligent techniques (cf. [1]). Survey participants were mainly CoIL nodes from industry and business, representing the following sectors:

- *primary and process industries* (metallurgy, oil/petro-chemical, mining, glass, cement, building, power, etc.)
- *trade, finance R&D and services* (banking, insurance, logistics, tourism, transportation, home and personal care, informatics, etc.)

The survey revealed some interesting facts on the present and future of intelligent technologies. First, most of the respondents were found to have a good level of acquaintance with intelligent technologies, which was not surprising as all were CoIL nodes and they had inevitably come into contact with at least one technology. The survey also showed that intelligent technologies retain their main impact and expected applications in traditional industrial areas, such as decision support systems and quality control. In addition to that, they were beginning to be used in some emerging application areas, such as e-commerce. With respect to the current/ future trends in the use of intelligent techniques, it was found that in most applications both individual and hybrid technologies were gaining ground. Still, hybrid systems were not as popular as individual intelligent technologies. Responses also showed that nodes had already benefit from applying intelligent technologies but they expected more for the future.

In this paper, we present a survey, similar in nature to the aforescribed, whose purpose is to draw a picture of the popularity of intelligent techniques in a particular business sector, the medical industry. This survey is sponsored by EUNITE² and addressed to companies and organisations, specialised in various sectors of medical business (medical technology and equipment, medical computing and computer systems, medical management and consulting, pharmaceuticals, etc.). Since research is still in progress, our discussion is more focused on methodological issues. In section 2, we present the sample and the objectives of our survey. We also analyse the design of the questionnaire used for collecting the relevant information from medical companies and organisations. Section 3 attempts to sketch some general tendencies or attitudes, as revealed to us from the early stages of the survey. Finally, section 4 concludes the paper and sets future directions for our research.

2. METHODOLOGY OF THE RESEARCH

In this section, we discuss some methodological issues related to our survey. We start with describing the sample and we then move on to analyse the objectives of our survey. Finally, we discuss the principles underlying the design of our questionnaire.

SAMPLE SPECIFICATION

The sample of our research consists of companies or organisations specialised in either of the following business fields:

- *Medical technology*; meaning all kinds of medical equipment, apparatuses, instruments, packaging material, etc. Production-line technology is also implied.
- *Medical Information Systems*; various aspects of information systems for medical or healthcare applications (medical software, medical networking, computer integrated systems, etc.)
- *Medical Management*; referring to companies offering management or consulting services to healthcare providers, such as hospitals or clinics.
- *Pharmaceuticals*; referring to pharmaceutical products.

Although the above taxonomy serves well for methodological purposes, it does not occasionally reflect the reality in medical business. Many medical companies show high degree of product diversification and therefore are activated in more than one of the fields given above.

¹ More information on the objectives and the activities of the Computational Intelligence and Learning Cluster can be found in CoIL's website at <http://www.dcs.napier.ac.uk/coil/>.

² EUNITE is a Network of Excellence funded by the Information Society Technologies Programme (**IST**) within the European Union's Fifth RTD Framework Programme. The Network has founded with the purpose to 'join forces' of Intelligent Technologies for exploiting the potential of their synergies towards building Smart Adaptive Systems and promoting their practical implementations. It has started on 2001 and now consists of more than 90 (active) nodes (universities, research institutes and industries) from all across EU. For more information on the EUNITE Network see <http://www.eunite.org/>.

OBJECTIVES

Several issues were addressed in this survey. First of all, we were interested in investigating the current status of intelligent technologies/techniques in medical industry. How familiar are the actors of medical business with intelligent methodologies and to what extent are intelligent techniques used in any of the above sectors of medical industry? Of extreme importance was also to get an idea of how medical entrepreneurs see intelligent methodologies. Are the latter capable of solving problems arising in medical industry? Are they amongst the effective ways to do that? How profitable they are compared to standard and 'less intelligent' techniques?

Another issue, also of great importance, was to investigate the future perspective of intelligent methodologies in medical industry. For that purpose, sample companies were asked about their business priorities and about whether their prime business interest focuses on the adoption of intelligent technologies or on other 'prerequisites' like construction of databases, electronic data interchange, data processing, etc. In that way, we could gain a picture of whether medical companies and organizations are in fact ready to adopt 'intelligence' in their products and/or their structure. Very important for the future of intelligent technologies in medicine is also to learn how much actors of medical business count on IT. Would they be willing to learn more on intelligence technologies? Would their companies invest on adopting intelligent techniques and possibly training their personnel on them? Is it likely that intelligent techniques become a competitive advantage for those who will use them in the future?

Among the primal goals of our research was to correlate responses on the questions addressed above with various sample variables such as:

- a) The *size* (or *growth*) of the company taking part in the survey. Several variables were used to measure the size or growth of the company: the number of employees, the annual turnover, the degree of product or activity diversification, possible participation in joint-ventures, etc.
- b) The *geographic area of action*. This is the country or continent that the company is activated in. We are also interested in learning whether each company acts on a national or international level.
- c) The *thematic area of action*; this is the medical business sector(s) that the company is specialised in.
- d) The *intensity of market competition*; this is referred to the intensity of competition in the market that the company is mainly developed in.

QUESTIONNAIRE DESIGN

Some general rules of thumb, which are suggested in the literature (see for example [2]-[5]), were incorporated into the design of our questionnaire. Those rules apply to almost any kind of survey involving questionnaires and seem to work well in practice.

In principal, most of the questions were posed in a multiple-choice format, prompting for particular responses. Those are usually termed in the literature as *closed-format* questions, in contrast to *open-format* questions which do not include a predetermined set of responses and the participant is free to answer however he/she chooses. The latter type of questions was generally avoided as it suffers from several disadvantages.

First, the very nature of open-format questions makes them difficult to be processed by an analyst. There is no way to automatically tabulate or perform statistical analysis on them, which means that they usually have to be considered one-by-one. This is obviously more costly in time and money, and may not be practical for time-sensitive evaluations. Open questions may also require more thought on the part of the participants and may cause them to lose interest on the questionnaire sooner. Closed-format questions, on the other hand, offer many advantages in time and money. By restricting the answer set, it is easy to calculate percentages and other hard statistical data over the whole group or over any subgroup of participants. Last but not least, closed-format questions allow the researcher to filter out useless or extreme answers that possibly occur in an open-format question.

Since in a closed-format question it is difficult, and sometimes risky, to predict in advance the exact number of responses, care was taken to include a no-opinion or an 'other' type of option, whenever applicable. In each case, the presence of such a neutral option was counterbalanced by a broad range of answers so that the no-opinion choice is not over-utilised, especially by non-enthusiastic questionnaire takers. Part of our questionnaire were also questions asking for company's or contact person's details, as a means to correlate response sets between different groups of companies or participants. Attention was paid, however, to ask a minimal number of such questions, as those are often "inconvenient" to answer. Whenever confidential questions were unavoidably included (e.g. questions asking about the growth of the company), we tried to form them as unobtrusively as possible in order to avoid ruffling participants and

causing them to respond less truthfully. This was actually a general principal underlying the phrasing of most questions asked in our survey.

The questionnaire was implemented in Microsoft Excel© version 2000 using some additional features, such as option buttons, check and text boxes³. Each cluster of questions is organised in a single spreadsheet, while 'backward' and 'forward' hyperlinks help the user move from one part to the other, following thus a serial procedure. At the end of the questionnaire a command button was put which allows the automatic delivery of the questionnaire file to the organiser of the survey. The purpose of using a computer-based questionnaire with those additional features was to make a user-friendlier environment for the respondent and, most important, to minimise shipping and processing times from both sides of the survey (respondents and analysts).

The objectives of our survey, presented in the previous paragraph, served as a guideline for the structuring of our questionnaire. As a natural consequence, the set of the questions addressed to the respondents were divided into four clusters: those asking about 1) the current status of intelligent technologies in medical business 2) the future perspective 3) the status of the represented company and 4) administrative information (contact person's and company's details).

In the sequel, we analytically describe the questions falling into each of the above categories.

Current Status of intelligent technologies in medicine

This part of the questionnaire includes four questions. The first one investigates the familiarity of the respondent with intelligent technologies and techniques. Instead of prompting for a direct response, such as 'Yes, I am familiar with such technologies' or 'No, I am not', we rather ask the participant to identify the following types of technologies:

- a) Intelligent web browsing/search engines
- b) Intelligent data analysis/data mining/decision support
- c) Smart algorithms for image processing
- d) Business intelligence/knowledge management
- e) Fuzzy logic controllers

as those are, in our opinion, popular applications of 'intelligence'. This way of posing the question helps both analyst and participant to establish a common language of communication and, most important to avoid any misinterpretation of subtle terms, such as 'intelligence'. It will further allow us to correlate acquaintance with any of the above systems with the type of the company or the position of the person been contacted.

Question 2 asks the participant to identify, if possible, intelligent products/solutions/methods within his\her business or organisation environment. On a positive response, we further ask for the particular sectors including such intelligent systems, by providing the following list of responses:

- a) Medical Software, Computer Integrated Systems, Computer tools & Applications
- b) Hardware, apparatuses, devices, manufacturing lines
- c) Medical Services/Monitoring/Support
- d) Managerial Decision Support, Data Analysis, Web services
- e) Other

In the latter case, the respondent is prompted to briefly state which.

The third question investigates how actors of medical business currently see intelligent technologies. Again, the following list of responses is given:

- a) Capable of solving problems arising in medical business
- b) More profitable compared to less 'intelligent' and conventional techniques
- c) Not at a stage to make profit yet
- d) I do not have any concrete opinion on the topic
- e) Other (please, briefly state which)

³ A copy of the questionnaire file can be downloaded from http://decision.ba.aegean.gr/pubs/EUNITE/Questionnaire_Medical_Business.xls.

Future perspective of intelligent technologies in medical business

This part of the questionnaire comprises five questions. The first one, labelled as 'Question 4', asks for the business priorities of the company that the respondent represents. This is also a closed-format question including the following set of responses:

- a) Electronic Data Interchange (EDI)
- b) Construction of Databases
- c) Data processing
- d) Adoption of Intelligent technologies/methodologies
- e) Other (please, briefly state which)

Note that responses, in this case, are presented in a logical order, as typically the adoption of intelligent technologies (option d) presupposes a, b & c.

The next question (q. 5) asks for the respondent's opinion on whether intelligent technologies are likely to become a competitive advantage for those enterprises that will adopt them in the future. Three equally distributed answers are provided here (quite, fairly and hardly likely), along with a no-opinion choice.

The following two questions (g. 6 & 7) investigate the tendency of medical companies/organisations towards intelligent technologies: Would they be interested in keeping track with latest developments? Would they invest on training their personnel (employees and executives) on this subject? The answers provided for both questions were three: 'Yes', 'Maybe', 'No'. In the final question of this part (question 8), we ask for the particular areas of company's business activity which would, on the participant's opinion, attract intelligent technologies/techniques. We have exceptionally chosen this to be an open-format question, as we didn't want to prejudice the respondent in favour of certain options and, therefore, prompt him\her for a particular response. Allowing for possible ignorance on the behalf of the participant, we have also given the alternative choice 'I am not sure'.

Status of the participating company

In the third part of the questionnaire, we attempt to elicit certain pieces of information regarding the company's internal or external environment. This information will help us to correlate responses to the previous parts with several sample variables presented in the previous section.

In question 9 we inquire into the intensity of competition in the market that the company is mainly developed in. The possible responses are three: high, medium, low. Question 10 prompts for approximate estimations of the number of employees and the annual turnover of the company. Question 11 asks the respondent to describe the main areas of his/her company's business activity. The following options are given:

- a) Medical Technology & Equipment
- b) Medical software & computer systems
- c) Medical management & consulting
- d) Pharmaceuticals
- e) Other (please, briefly state which)

Finally, question 12 investigates the company's level of business activity (national/international).

Administrative information

In the fourth part of the questionnaire, we inquire for some further details regarding a) the company being represented (name, location of the headquarters) and b) the contact person being enquired (title, name, surname, position held at the company, email address). In particular, the position of the contact person is of special interest, as we want to explore the relation it has with the various response sets. The last two questions of this part are of mostly feedback nature; the one prompts for some comments on the survey or the questionnaire itself and the other asks whether the represented company would be interested in receiving a full report on the results of the survey. The fact that participating companies are entitled to the results of our survey was thought to be a good motive for taking part in the survey and, hence, it was announced to the participants in advance. The reasoning behind this policy is that any respectable company would like to gain a picture of the strategy of similar, and possibly competitive, companies regarding intelligent technologies.

3. FIRST RESULTS ON THE SURVEY

As a first step, we contacted via email more than 500 medical companies or organisations, inside or outside Europe, requesting for details (name, phone number, email address) of any person in the company being suitable to express his/her opinion on the matters of our survey^{4,5}. However, this was not always feasible and frequently it took several working days for our message to reach the proper person. Once contact was established, arrangements were made to send the excel-based questionnaire along with some supplementary pieces of information (purpose of the survey, description of EUNITE and its activities, background definitions, etc.).

In parallel with emails, a session of telephone contacts was also organised with as many companies of our sample as possible. This was an attempt to give the contact a more personal character by directly informing people on the objectives of the survey and the purpose of EUNITE. As expected, telephone contacts enforced the participation in the survey.

Despite the various contacts, we think that our research is at a stage where quantitative conclusions cannot be safely drawn yet. The size and the quality of the sample being accumulated hardly allow us to detect interesting dependencies between response sets and sample variables. However, as among the companies responded to our call were some leading ones in the medical business sector (cf. General Electrics Medical Systems, Toshiba, etc), we believe that we are in a position to give some general trends and early results, mostly of qualitative nature.

In general, the current sample consists of medium to large companies being equally distributed among the various medical business sectors (equipment, information systems, management, pharmaceuticals, etc.). Most of the companies having responded to our call are based on Europe, while there were also few from US and Israel. The majority of represented companies seem to be activated on an international level, usually, under modest to keen market competition.

As regards the current status of intelligent technologies in medicine, it seems that intelligent web browsing/search engines, intelligent data analysis tools, smart algorithms for image processing and knowledge management are quite popular among medical entrepreneurs. In contrast, almost half of the participants are not aware of fuzzy logic controllers. Encouraging is the fact that the majority of participants were able to identify intelligent products, solutions or methods within their company's business activities, especially everything that has to do with software and networking applications, data analysis tools and web services. As regards the attitude towards intelligent systems, most of the participants seem to have a concrete opinion on the topic, sharing the view that intelligent technologies are capable of solving problems arising in medical business. The latter somewhat justifies the existence of intelligent systems in most of the companies being questioned. The level of agreement on the profitability and the effectiveness of intelligent technologies (options 3.2 & 3.3) is lower.

As far as the future perspective of intelligent technologies is concerned, answers are almost equally distributed among the various options of question 4. Almost half of the respondents have stated that the adoption of intelligent technologies is one of their business priorities. Furthermore, the majority of respondents expect that intelligent technologies are likely to become a competitive advantage for those enterprises that will adopt them in the future. Most of the companies would also like to keep track with latest developments in intelligent technologies, by joining, for example, a EUNITE-type Network of Excellence. However, in contrast to their interest, they are still reluctant to invest money or other resources on intelligent technologies. As regards possible areas of application of intelligent systems, responses vary with to the business sector in which every company is specialised. It seems however that there is space for intelligent solutions in medical applications.

4. CONCLUSIONS-FURTHER RESEARCH

In this paper, we present a survey on the penetration of intelligent technologies and techniques in medical industry, conducted on EUNITE's behalf. More than five hundred companies and organisations were contacted, which are specialised in various sectors of medical business, such as medical technology and equipment, medical computing and

⁴ Among the various candidate respondents, priority was given in a decreasing order to the head of research & development, the director of the production line, the marketing manager and the sales manager.

⁵ Although EUNITE is mainly associated with companies and organisations within the EU zone, we thought that extending the scope of our survey to other continents would give us the opportunity to investigate whether there are any significant changes in business attitudes between European and non-European (e.g. U.S.) companies.

computer systems, medical management and consulting, pharmaceuticals, etc. As our survey is still at a stage which does not enable us to perform thorough statistical analyses, we have rather given our paper a more methodological character. Apart from the sample specification, we analyse the objectives of our survey and discuss the principles and ideas underlying the design of our questionnaire. In addition to methodological issues, we provide some early results in an attempt to detect in advance general trends or attitudes regarding intelligent technologies and techniques. As our survey progresses, our next goal is to explore interesting relations between response sets and various sample variables, such as the growth of company being questioned, the intensity of market competition, the geographic and thematic area of action, and so on. Those are thought to have a strong influence on the way that medical companies or organisations see intelligent technologies.

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