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# A Knowledge-Based Entrepreneurial Approach for Business Intelligence in Strategic Technologies: Bio-Mems

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**ABSTRACT**

We propose a knowledge-based entrepreneurial (KBE) approach for business intelligence in strategic technologies at industrial sectors. The KBE approach is at the convergence of business intelligence and knowledge management and is used for advising users in business decisions and potential risks. Our approach comprises both a technology roadmap model as well as a knowledge-based entrepreneurial portal for various technologies. We use the Biological-Micro-Electrical-and-Mechanical-Systems industry (Bio-MEMS) to illustrate the approach. The technology roadmap model identifies the main actors, defines their roles and specifies the issues to be addressed. It handles information about main products, market trends, companies, research centers, application domains, products, standardization, and intellectual properties issues. The portal provides knowledge about the main actors through automation facilities based on digital libraries, searching and knowledge extraction from databases, data-ware houses and the Web. We explain how the KBE is helping Bio-MEMS users in business analysis.

**Keywords: Business Intelligence, Knowledge Management, Bio-MEMS**

## INTRODUCTION

Several approaches have been proposed for competitive intelligence analysis in technology-based business sectors and to manage the knowledge in those sectors. The knowledge-based entrepreneurial approach (KBE) proposed in this research combines both knowledge management (KM) and business intelligence (BI) methods in an integrated environment to serve user needs. BI helps with methodologies, tools and roadmaps that produce useful information about new products, market studies, global macroeconomic indicators, research activities and main players in strategic fields. KM provides means for assisting in generating value from the knowledge assets, intellectual capital and technologies of an organization. Micro-electrical and mechanical systems (MEMS) and in particular Biological MEMS (Bio-MEMS) are examples of emerging fields with a fast growth in the recent years. Several roadmaps that integrate business intelligence and knowledge management have been proposed and are being used in this field. These roadmaps present relevant information such as market trends, population growth, economics parameters, demand and mobility, legislative laws in the use of these technologies. Nevertheless, their outputs are often static, proprietary and for sell printed documents that are not updated until the next for-sell edition is published and for this reason they become obsolete very rapidly. In this research we present an approach that comprises both a BI roadmap methodology as well as Web-based portal for managing information and knowledge for strategic technologies that serves users interested in the field. The principal contribution and the novelty of the KBE approach is the construction of a dynamic environment for developing business intelligence studies which makes it different from roadmaps commonly found in competitive intelligence analysis. Although in this research we focus on Bio-MEMS, the approach is applicable to other strategic technologies such as biotechnology, nanotechnology, cyber-security and wireless technologies and industries that include automotive, telecommunications, pharmaceutical, and many others.

This paper is organized as follows: first, we describe the background and related work, next we explain the knowledge-based entrepreneurial approach then we describe the roadmap model, the KBE portal, and the Bio-MEMS industry as a case study; finally, we present the conclusions and future work.

## BACKGROUND AND RELATED WORK

Business Intelligence is an active field that spans research, academic, professional and business activities (Vitt, Luckevich and Misner, 2002). It employs knowledge extraction and data mining techniques from statistics, computer science, and artificial intelligence to learn useful patterns and knowledge hidden in large volumes of data that arises from business operations and transactions in an organization (Anandarajan M., Anandarajan A. and Srinivasan, 2004). It builds over the theory of knowledge management and uses its methodologies, techniques and best practices for creating value from the knowledge assets of an organization for serving its clients in the best possible way in order to meet the company goals (Liebowitz, 1999, 2004). Data, text and web mining techniques are used to drill into corporate data bases and data-ware houses for discovering knowledge that otherwise would be very difficult for a human being to be aware of (Berry and Linoff, 2000).

Digital libraries are useful in storing and organizing massive information about a knowledge domain. An example of a digital library platform is the *Phronesis* System that uses a wide range of open-source technologies for its implementation (Salinas and Garza, 2004). On the other hand, there's a big amount of knowledge and information available in the Web. The challenge is to access that knowledge in a fast and efficient way in order to obtain relevant information for decision analysis. There are tools both open-source and proprietary for knowledge extraction from databases, digital libraries, data-ware houses and the Web. One of them is *LIXTO*, a powerful tool property of the company Lixto Software GmbH in Vienna, Austria. LIXTO allows automatic extraction of structured data from Web sites and information portals and generates XML data output (Diaz Prado, 2005). Another tool is *Just in Time Information and Knowledge (JTIK*), a multi-agent based intelligent framework equipped with automated deduction through rule-based systems that is property of the authors' university. It uses agents and Web services for searching and monitoring data bases and home pages (Aguirre, Brena and Cantu, 2001).

MEMS arise from the integration of mechanical devices, electronic circuits, sensors, actuators and other elements in a common silicon substratum through technology of micro machining. The electronics side is based on CMOS integrated Circuits (IC), the mechanical components are made using processes of micro machining that selectively records the tracks in the absent parts of the silicon capsule and adds new structural layers to form the mechanical and electromechanical devices. MEMS technologies have an ample rank of applications that include automobiles, telecommunications, aerospace, personal devices, global-positioning systems, bio-chemistry, health and medical equipment among the main areas.

The Bio-MEMS field is understood as the application of MEMS technologies in biology, chemistry, environment, health care and medicine. This industry has demonstrated its great potential in diverse areas of medicine and most important, it contributes in improving the quality of life and health of human kind. The Bio-MEMS industry is at an emerging stage of its development. The MEMSTAND Survey Analysis (Cui and Leach, 2003) reports that standards in a field are established when a technology is at a maturing stage, which is not the situation for MEMS and for this reason standards are not found yet.

BI/KM is often applied to strategic, technology oriented domains yielding roadmaps for advising users in technology trends and business opportunities. An example of such technologies is MEMS. There are several roadmap approaches for MEMS among which are the *NEXUS Microsystems Product-Technology Roadmap* (NEXUS, 2003) developed in Europe, the *Microsystems Research in Japan* (Howe et al,.2003) developed in the USA, and the *MANCEF Microsystems Top Down Nano Roadmap* (Elders and Walsh, 2002) developed in the USA that spans an international scope, among others.

## A KNOWLEDG-BASED ENTREPRENEURIAL APPROACH

The Knowledge-based entrepreneurial approach proposed in this paper is at the convergence of business intelligence and knowledge management concepts, methods and tools for advising users in decisions regarding technology trends, market size, competitors' market share, as well as investment and expected ROI for a given industrial sector. The BI aspect considers various kinds of sources like databases, roadmaps, surveys, benchmarks, patent morphology analysis, prospective studies, customer relationship management and the like, and uses data analysis techniques to find useful information and knowledge for advising users in business decisions. KM facilities include an ontology framework, digital library tools, knowledge extraction mechanisms, knowledge distribution facilities, queries and reports, exchange formats, representation standards like XML and other technologies in order to advise users in creating value from the knowledge assets of an organization. BI and KB share the use of knowledge discovery techniques from data bases (KDD), data-ware houses, digital libraries, spreadsheets and from the Web. This functional view of our KBE approach is illustrated in figure 1.

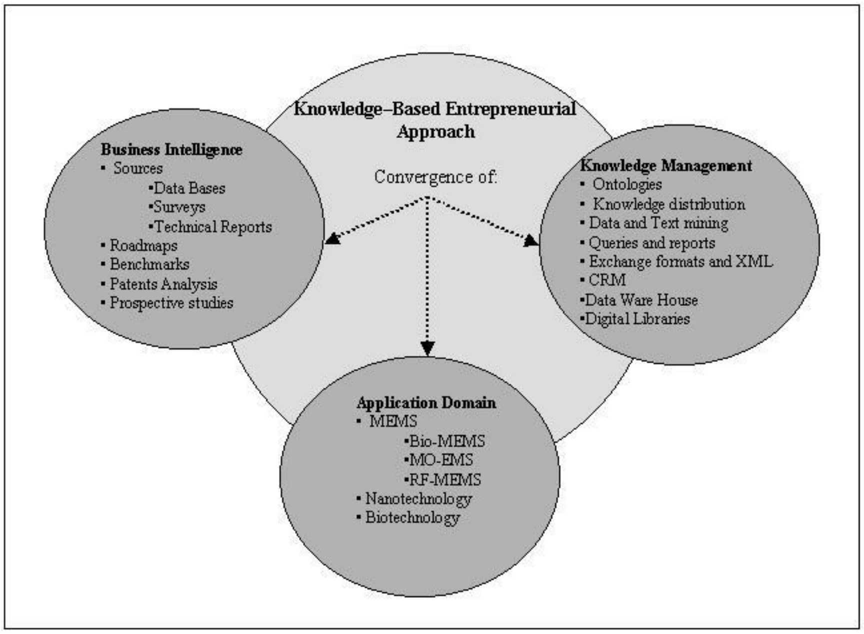


Figure 1. Functional view of the Knowledge-based Entrepreneurial Approach

The KBE approach comprises a roadmap model for doing business intelligence analysis in a given field and a knowledge-based entrepreneurial portal that provides a computer framework for knowledge extraction and knowledge management. Portal features include various kinds of databases, data ware-houses and URL repositories; digital libraries, user interface, user authentication, knowledge extraction, distribution and reporting. A traditional roadmap focuses on the outcomes of a BI study but sometimes they hide the processes and methods employed for building the roadmap. Our approach extends a traditional roadmap approach by providing a computer framework for obtaining information and knowledge from the data sources. The extracted information and knowledge become technological drivers such as indicators, trends, correlations, distributions and other elements that prove useful in decision making. This structural view of our KBE approach is illustrated in figure 2. We present in the following two sections a description of the roadmap model as well as the KBE portal.

## THE ROADMAP MODEL

A roadmap is a standard tool in sectors such as the micro-electronics and automotive industries. We propose a roadmap model to guide in constructing roadmaps for business intelligence. The model is conformed of three elements: a group of six actors, a set of issues to be addressed for each of these directives, and a set of technological drivers that guide the search for answers to the proposed issues using the automated aids provided by the KBE Portal. The six actors we identified are the following:

- Industry market
- Research and development centers in universities and companies
- Governments
- Investors
- Non-for-profit organizations
- Intellectual property organizations

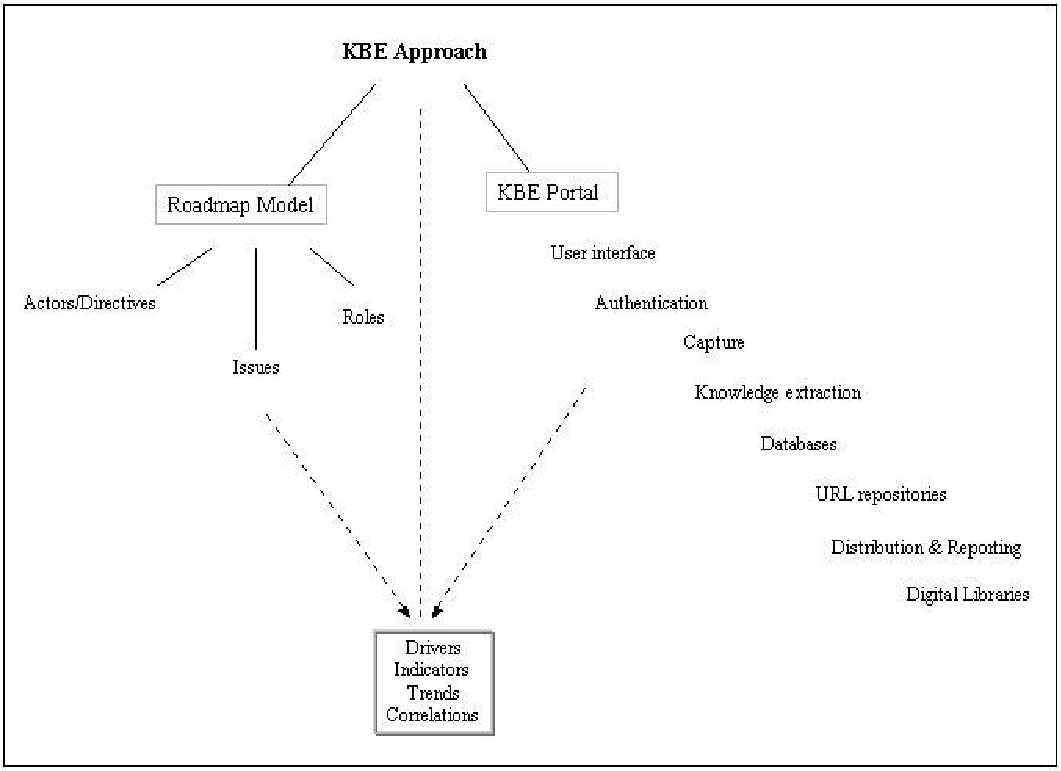


Figure 2. Structural view of the Knowledge-based Entrepreneurial Approach

Figure 3 displays the roadmap model actors and their roles. There are typical issues that must be addressed for each of these actors whose answer show the status of the field and provide highlights about areas of opportunity for either new research areas or investments.

The *industry market* is conformed of global market trends and microeconomic information about a block of countries or region of the world, companies competing in that market and information about their market share, *customers*, suppliers, stock market, application domains, products, mergers and alliances, technologies in place and innovations in materials and fabrication processes, as well as standards adoption. Information about these issues are important for diagnosing an industrial sector to determine its current stage, its maturity, and the business opportunities it represents.

*Research and development centers* at universities and companies are essential for business competitiveness since strategic industries are technology oriented. The model includes a comprehensive list of research and development centers in the field with information about their affiliations, lines of research, infrastructure, researchers, patents, licensing procedures, research expenditure, scientist education, rankings and related information. This list is built both by Web search and from reports analysis.

*Governments* play a key role in economic development. Economic blocks are integrated by countries whose government*s* typically enforce public policies for R&D priorities and macroeconomic development as well as legislation, research expenditure, intellectual property regulations, foreign investment policies, cooperation agreements, level of population education, labor capacities, national resources, labor union policies and other related issues that become important for investment decisions.

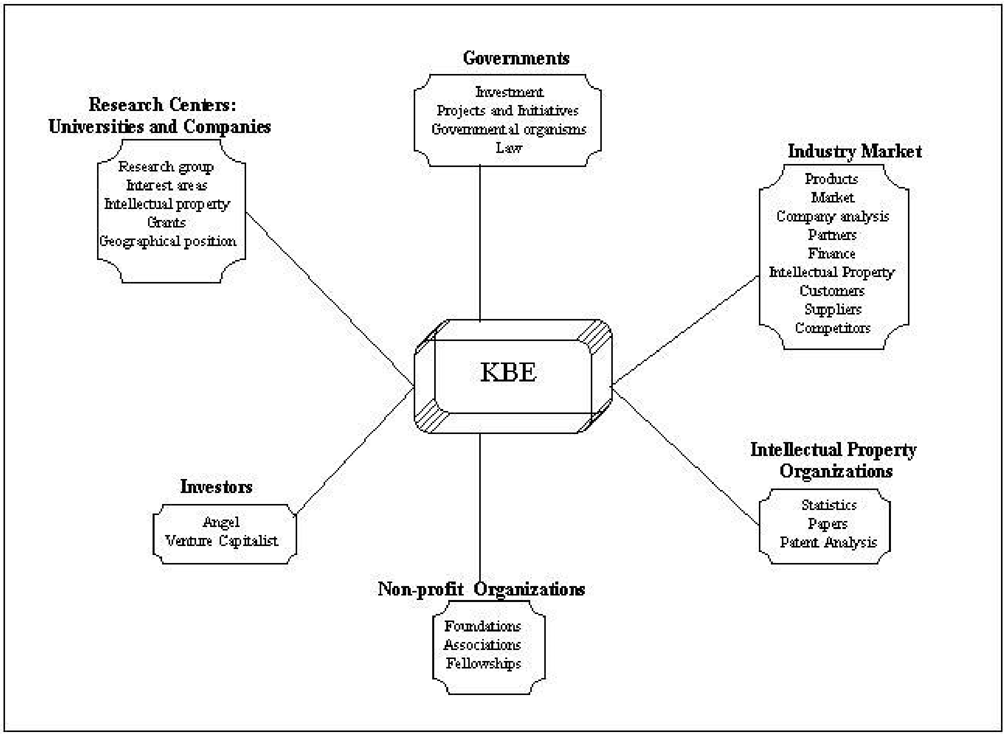


Figure 3. The roadmap actors

*Investors* information angel investors and venture capitals becomes useful for technology licensing, start-up companies, government officials, research centers, and other players in an industry market. The roadmap models searches all the available sources for building a data base of investors. It also provides aids in investment scenario analysis and prospective return on investment (ROI) calculations.

*Intellectual property* regulations in companies and countries are another actor of the model. The roadmap model considers relevant aspects such as statistics about patents per county, economic block, company, product or application domain; morphological analysis of patents, piracy practices and regulations, international treaties and intellectual protection agencies.

*Non-for-profit* organizations such as professional, scientific and non-governmental organizations are considered by the roadmap model as they may influence aspects of an industrial market. Examples are human rights, environment protection, democracy, standardization associations, United Nations agencies and others.

The *roadmap modeling* yields outcomes for each of the six actors that include reports with information about market trends, patterns, indicators, rankings, correlations, graphs, distributions, statistics, listings, benchmarks and other useful information for decision analysis. The following section describes the automation facilities of the KBE portal.

## THE KNOWLEDG-BASED ENTREPRENEURIAL PORTAL

The Knowledge-Based Entrepreneurial Portal is a computer framework that supports and complements the roadmap model with automated analysis facilities for data acquisition, storage, organization, and knowledge extraction and distribution. Data is acquired from information sources that include hardcopy materials, web home pages, databases, data-ware houses and digital libraries with text, images and videos. The purpose of the data extraction process is to help users in finding the roadmap outcomes. Extraction is supported by a set of data and text mining, and morphological analysis tools. This process is illustrated in figure 4.

Some of the information source is hardcopy printed materials like books, manuals, journals, magazines, status reports, or proprietary roadmaps that must be bought from publishers or professional associations. Automating search in these materials is more difficult and an analyst who reads and extracts from these sources the material that is relevant is needed. Alternatively, provided copyrights are preserved, these materials may be digitized with permission from the authors and publishers. In any case, the outcome goes to a digital storage in a word processing document, spreadsheet or database.

A great deal of information both public domain and proprietary is found in web pages. This information is about companies, products, foundations, associations, etc. Reports, trends and bench-markings are found this way. Electronic files like data bases, document repositories, software tools and other sources are found in the internet. Some are proprietary and some are public domain.

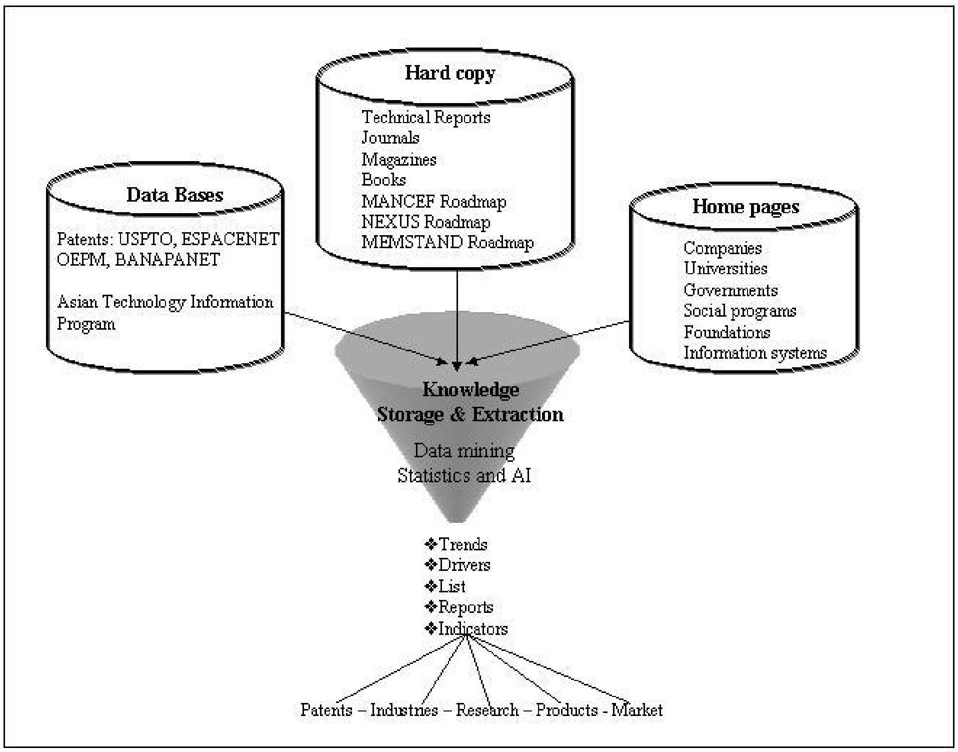


Figure 4. Knowledge extraction process

Source information is organized in the KBE Portal through a digital library and internal databases. The *Phronesis* digital library was used for storing, searching and exchanging electronic documents. The databases were implemented in the open source *My-SQL Database server* that offers multi-storage engine architecture, flexibility, database management system, speed, compactness, stability and cross-platform support. The KBE portal architecture is depicted in figure 5. The URL is available upon request.

### Knowledge Extraction and Data Analysis Techniques

Knowledge extraction facilities are an important element of the KBE Portal. The extraction is supported by data mining, pattern recognition and statistical analysis techniques. Data mining techniques include decision tree learning that use the entropy, GINI index and CHAID rules. Pattern recognition techniques cover neural network and Bayesian network learning. Among the statistical analysis tools we find filtering and classification such as averaging, regression, correlation, clustering, analysis of variance and hypotheses testing. By combining various techniques we construct the roadmap outputs. In the current implementation of the KBE Portal knowledge extraction is done off-line using a data mining environment developed by the authors and their students (Cantu et al, 2005). The Portal generates electronic files that are converted into data mining tables for knowledge extraction. Document data analysis is carried out through the search engine implemented in the Phronesis digital library. Currently, URL search in the Web is done by using public domain search engines.

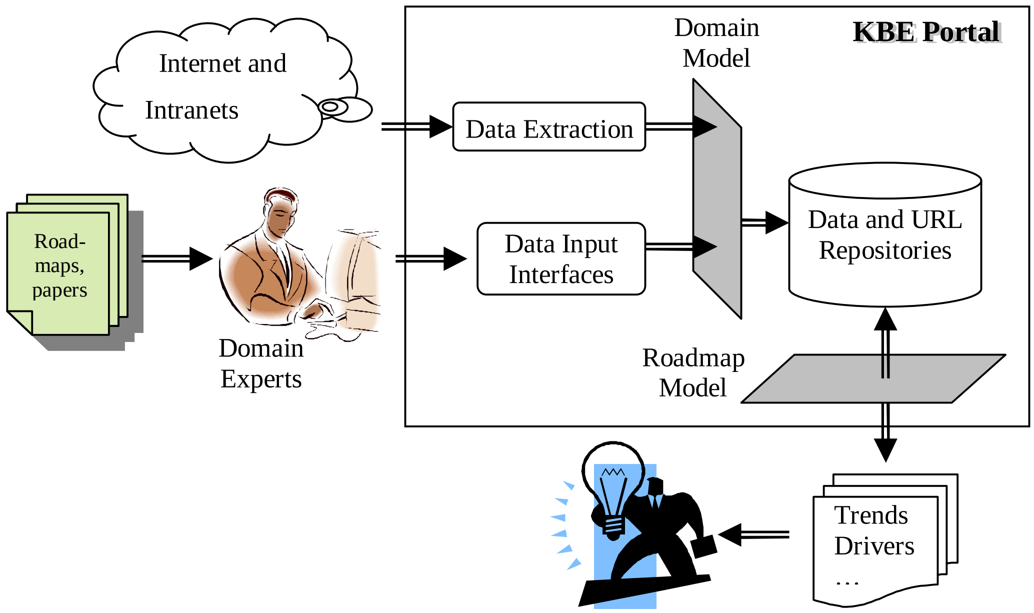


Figure 5. KBE Portal Architecture

### THE BIO-MEMS CASE STUDY

The KBE approach is now illustrated with the Bio-MEMS case study. We describe the roadmap model in terms of its six actors, roles and issues. The KBE Portal proved useful in organizing and extracting the relevant information for this industry by way of its automation facilities. We follow the roadmap model to guide the analysis of the Bio-MEMS sector and explain the main findings, results and recommendations.

The actors of the roadmap are formed by a worldwide **industry market** survey of 180 companies, their main products, areas of application, market share, new materials, fabrication processes and standards; a group of 113 **universities** with research centers and programs in Bio-MEMS; the programs supported by the **government** of the United States, Japan, and European countries like England, Germany, France and others and the situation of the industry in these countries; the statistics of 100 patents and **intellectual property** consideration in countries, companies, application areas and products; information about *investors* is summarized; and the main **non-for profit organizations** are identified including standardization agencies and scientific associations. Because of its importance, we analyze in more detail the **market industry** actor and its components and present an overview of the other five actors.

The **Industry market** components include Bio-MEMS market trends, the main companies, leading products, clients, and application domains. Other issues include fabrication materials and suppliers, manufacturing processes and standardization.

*Bio-MEMS market trends*. The Bio-MEMS industry has advanced quickly and new products have been manufactured. Medical equipment is already using this technology. This is because of its numerous advantages such as reduced size, low costs of mass production of devices in the same substratum, the great diversity of materials used and the high functionality and reliability they present. However, still there are obstacles, such as the governmental regulations that in the medical area are very strict, due to the extensive proofs, to the high R&D costs and to the lack of standards. The MEMSTAND Survey analysis has predicted that in the 2007 and 2008 the first standardization will be adopted. The Bio-MEMS tendency of growth predicted a market of 4 billions dollars for the 2004 and represented a 40% of the total MEMS market in 2003.

*Bio-MEMS companies*. The search for Bio-MEMS companies resulted in a list of 180 companies active in the field. The 180 companies were selected from the three most important economics blocks: United States, Asia–Pacific and the European Community. These companies were identified by reading specialized journals, business news paper, MEMS roadmaps and consulting specialized, commercial databases. The companies were selected by a specialized group and were fed into our data bases. Their country distribution is summarized in Table 1.

| COUNTRY | Bio-MEMS COMPANIES |
|---|---|
| United States | 66 |
| Japan | 28 |
| England | 15 |
| France | 5 |
| Germany | 21 |
| Switzerland | 6 |
| Sweden | 8 |
| China | 3 |
| Denmark | 10 |
| Others | 18 |
| TOTAL | 180 |

Table 1. Number of Bio-MEMS companies per country

*Bio-MEMS application domains*. The main Bio-MEMS application domains were identified in order to analyze general trends. The domains were used in the classification of Bio-MEMS products, companies and universities. Clustering statistical techniques were used for this purpose The application domains are the following:

- Diagnostic/Analysis: this domain includes biochemical analyses, biological tests in fluids or aerosols, in drug detection and diseases. Products for this domain are shown in figure 6.

| Biochips | | | | | | |
|---|---|---|---|---|---|---|
| DNA Chip | X | X | X | X | | |
| Lab on a Chip | | | X | | | |
| Microfluids Micro Chips | X | | | | | |
| ProteinChip | | | | | | X |
| GeneChip / Embryo Chip | | | | | X | |
| Otros | | | | | | |
| Immunological test | | | | X | | |
| | Drug investigation | DNA Analisys | Laboratory tests | Cancer diagnosis | Embryo fertilization | Protein analisys |

Figure 6. Biochips application

- Monitoring: this domain is about detecting biological signals. Products in this domain include glucose, pressure, blood and gas sensors
- Bio actuators and Implants: bio-actuators are used to reproduce mechanical actions through micro pumps and micro valves. Products include implants for ear prosthetics and seeing with artificial retinas.
- Medical instrumentation: this domain is about medical equipments and surgical instrumentation. Products include micro needles, micro cameras and micro robots.

- MEMS environmental technology: this domain is about pollution, water and gas analysis. Products include electronic noses for air pollution control.

Company statistics per application domain is illustrated in Table 2.

| APPLICATION AREA | Bio-MEMS COMPANIES |
|---|---|
| Diagnosis & Analysis | 44 |
| Bio sensors | 85 |
| Instrumentation & Equipment | 31 |
| Bio actuators & implants | 46 |

Table No. 2. Industry trends per application

MEMS applications for medical instrumentation and *Diagnostic/Analysis* are illustrated in figure 7 (NEXUS, 2003).

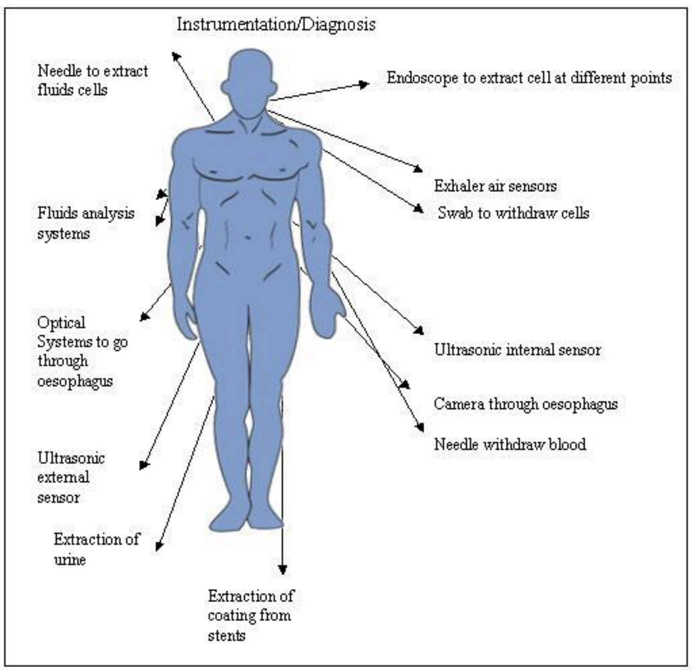


Figure 7. Bio-MEMS for medical instrumentation and diagnosis

MEMS application for implants and actuators are illustrated in figure 8 (NEXUS, 2003).

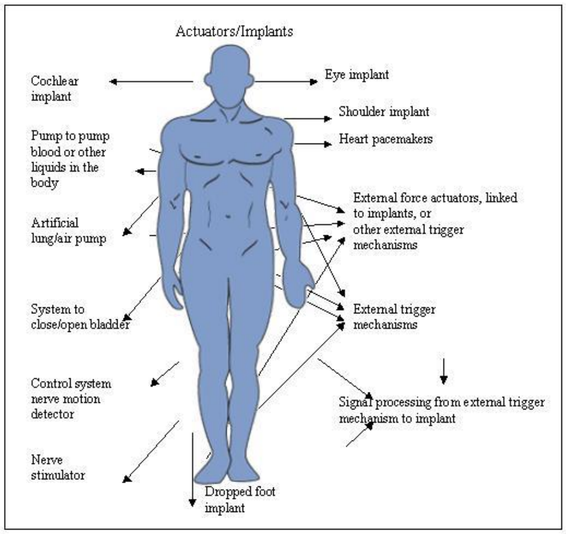


Figure 8. Bio-MEMS for implants and instrumentation

*Bio-MEMS products*. Bio-chips are considered killer application. They are used in detecting infectious diseases such as HIV, DNA analysis, proteins and genotypes. A market of 3 billion dollars for bio-chips was foretold for 2004. Predictions include a growth of 800% for DNA chips, 1000% for Protein chips, 1000% and 60% bilirubin analyzers 60% for new born. Figure 9 shows growth trends by product. Another market is the environmental technology based in MEMS used for polluting particle detection, explosives and drug detection and water analysis using electronic noses with sells in1998 of 200 million dollars and 900 million dollars in 2002.

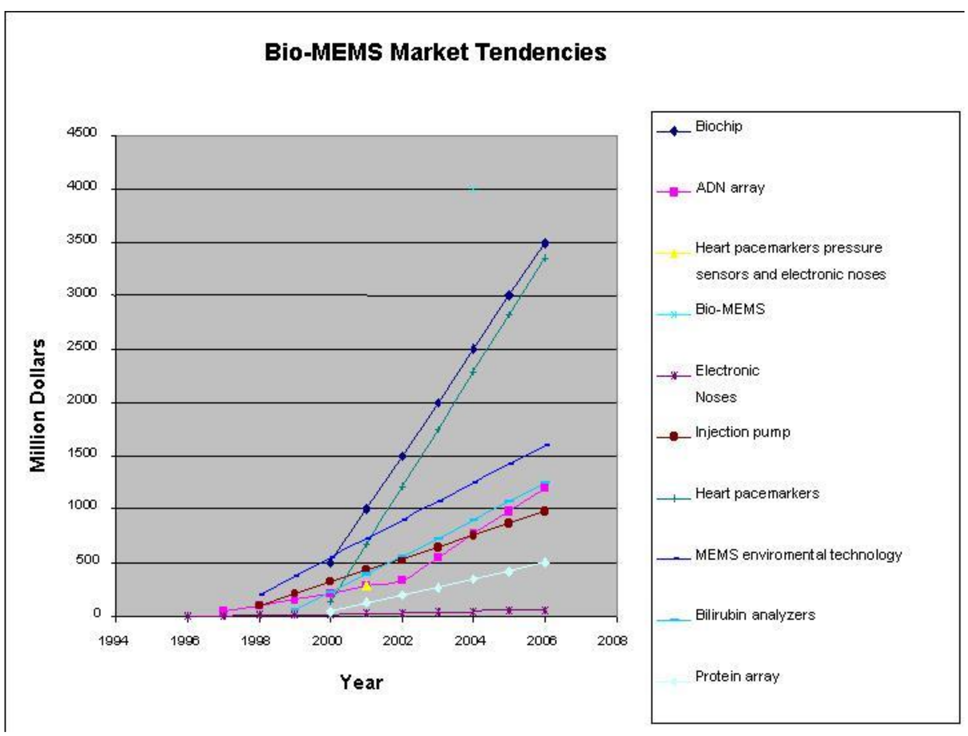


Figure 9. Bio-MEMS products trends

*Bio-MEMS Materials*. They own mechanical, optical, electrical or chemical properties that are used depending on the application. MEMS in biological and medical applications use materials different from silicon. Which is used In MEMS manufacturing. For Bio-MEMS materials such as carbon, polymers, polyamides, EAP (Electro Active Polymer), metal, ceramic, quartz, glass and SU-8 are commonly used.

*Bio-MEMS manufacturing and packaging* depends on the type of application and materials used. Manufacture technologies comprises assembling, packaging and testing. Bio-MEMS that use standard packaging are those that still use silicon materials, like pressure sensors, micro valves, micro pumps etc. Some of them had adopted standard packaging techniques like SOI (Silicon –on – Insulated) with bulk and surface micro machining or photolithography. Other packaging techniques are Flip Chip and Single Chip Integration commonly used in humidity and in vivo sensors. Commercial sensors that use SOI are electronics noses, ultrasonic gas sensor, DNA chips and pacemakers. Regarding manufacturing, Bio-MEMS that use a great variety in materials use LIGA (Lithographic Galvanoformung Abformung) micro machining, in commercial products like micro pumps, micro reactors, micro spectrometers, bilirrubin analyzers and micro engines. LIGA micro engines are used successful by European chemical industry and IMM, Mainz, Germany. Companies involved in Bio-MEMS commercial products, packaging techniques, manufacturing technology include Motorola, Biotronik, Nanogem, Genum and others.

*Bio-MEMS standardization*. There are no MEMS standards yet in manufacturing processes, materials, and terminology. Surveys consider that Bio-MEMS materials, size and forms, will be the first standards in 2007 or 2008 (Cui and Leach, 2003). Regarding materials standardization, substrates different from those used in semiconductors are considered. Packaging and bio compatibility are becoming standards in testing, optical measuring under mechanical and chemical conditions.

**Research centers in universities and companies**. Trends in Bio-MEMS R&D were considered for the three most important commercial blocks: Asia-Pacific, Europe and United States, in order to analyze the Bio-MEMS research tendencies. Asia-Pacific was the strongest in R&D in Bio-MEMS implants and diagnostic/analysis, and Europe in Monitoring and MEMS technological environment as shown in table 3.

| | Diagnosis & Analysis | Bio sensors | Implants | Environmental |
|---|---|---|---|---|
| United States | 19 | 11 | 6 | 0 |
| Europe | 16 | 17 | 6 | 4 |
| Asia-Pacific | 23 | 13 | 11 | 1 |

Table 3. R&D trends by economic blocks and application

**Governments: Bio-MEMS Investments and programs**. Research and infrastructure expenditure by governments in MEMS were also identified. Examples include the following: In Korea the nano-technology, biotechnology and information systems are considered the three highest priorities. In China, micro sensors and Bio –MEMS are also high-priorities with an emphasis in MEMS manufacturing and nanotechnology. In Israel, energy and water are high-priorities followed by telecommunications, nano-technology, bio technology and software. Also R&D in universities is concentrated in chemistry and materials. In Japan high-priority programs are supported by governmental founds and priorities are biotechnology, analytical chemistry and energy systems and micro generation. Industry and university interaction is increasing through specific MEMS programs and new university study programs based in MEMS (Howe et al, 2003).

Regarding **Investors** in Bio-MEMS, The KBE roadmap found information about potential investors in countries like Germany, Korea, the USA for a total of around 7 billion USD (Mora et al, 2004).

**Intellectual property organizations: Bio-MEMS Patents Trends and Reports**. Patent analysis in Bio-MEMS was carried out by searching for patents in various intellectual property data bases, like BANAPANET (Banco Nacional de Patentes del IMPI), USPTO (United States Patent and Trademark Office), ESPACENET(European Patent Office) and others. The KBE study selected 100 patents in medical areas as oncology, diabetes, ophthalmology, genetic, and clinical analysis using key words such as:

Biological MEMS - Biological Micro Systems - Biological Micro machines – Bio-MEMS-Nanotechnology and Micro-technology.

The KBE roadmap searched through the 180 Bio-MEMS companies in order to know their patents and their applications.. The roadmap identified patents issued in Mexico obtaining Bio-MEMS company reports by patents and medicals areas. Considering BANAPANET, USPTO and ESPACENET, Figure 10 shows the R&D Bio-MEMS tendency with respect to patents per country using USTPO.

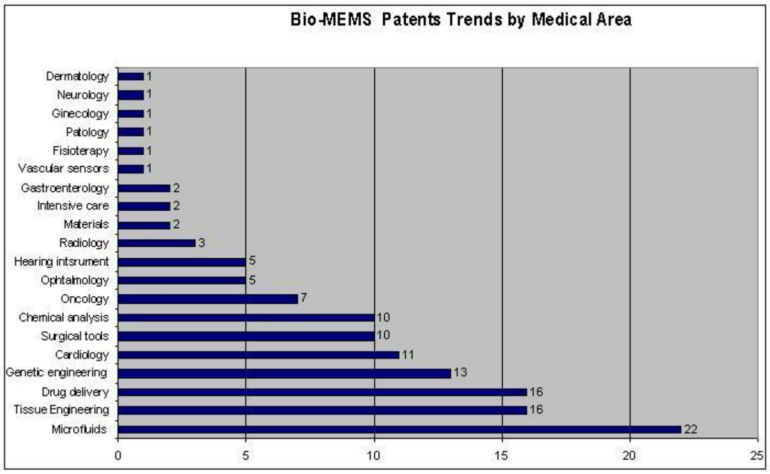


Figure 10. Bio-MEMS Patent Trends in Medicine

The KBE survey obtained around 50 non-for profit Bio-MEMS organizations that have invested in Bio-MEMS R&D (Mora et al, 2004).

The Bio-MEMS roadmap was obtained with the support of the *SITE–MEMS* (Sistema de Inteligencia Tecnologico Empresarial en MEMS) which is the name of the KBE portal for the MEMS application domain. SITE-MEMS was implemented in a Web environment using Hypertext Preprocessor (PHP), Java Server Pages (JSP), PHP-Collab, Phronesis, and other proprietary programming systems. The user interaction, navigation and manual data input are scripted in PHP that is a widely-used general-purpose scripting language, specially suited for web development and can be embedded into HTML. PHP-Collab is an open-source internet-enabled collaboration workspace for project teams. PHP-Collab architecture allows the consulting team to share information in one space and publish that information when desired to another space for the client, in addition encompasses the most important aspects of project management, such as task planning and document sharing, and hooks into other open source applications for bug tracking and content management, for ongoing project support. The SITE-MEMS provides a Web user interface shown in figure 11. It shows the user option for user collaboration, roadmap modeling, knowledge extraction and data analysis, search and web links.

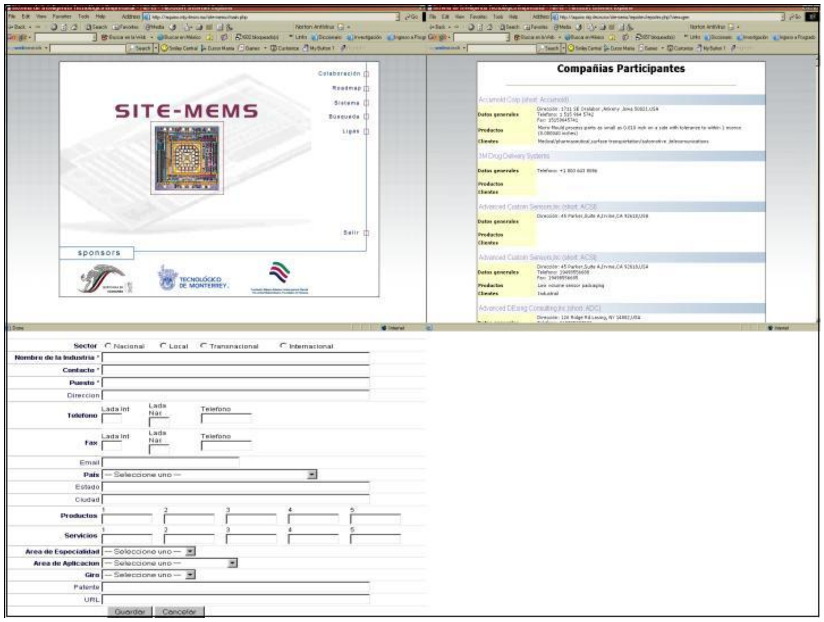


Figure 11. SITE-MEMS user interface

## CONCLUSIONS

We presented a knowledge-based entrepreneurial (KBE) approach for business intelligence in strategic technologies at industrial sectors. The KBE approach was used for advising users in decisions regarding prospective analysis and business decisions. Our approach included both a roadmap model as well as a knowledge-based entrepreneurial portal applicable to various technologies and industries. The KBE approach is supported by automated aids like a Web portal and data mining which include facilities to update data and knowledge bases in real time and in a continuous way. This is the dynamic feature of the approach. The second feature is transportability, which means that the KBE approach features are applicable to various domains We used the Bio-MEMS case to illustrate the KBE approach with a survey of 180 companies, 113 research centers and around 100 patents. The roadmap model identified the main actors and the roles they played. It provided information about products, market trends, companies, research centers, application domains, products, standardization, and intellectual properties issues. The portal uses automation facilities like digital libraries, searching and knowledge extraction from databases, data-ware houses and the Web. These facilities facilitate roadmap construction. The functionality of the portal will be improved with more statistics and machine learning techniques that will operate in an on-line environment.

## ACKNOWLEDGEMENT

This research was sponsored by the United States –Mexico Foundation for Science (FUMEC), the Ministry of Economy in Mexico and the Instituto Tecnológico y de Estudios Superiores de Monterrey. We thank Guillermo Fernandez de la Garza, FUMEC’s General Director for suggesting this project and we acknowledge the very valuable suggestions and guidelines that he contributed with during the development of the project. Finally, we acknowledge the very valuable suggestions of the anonymous referees that contributed to improve and shape this paper.

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