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Factors Influencing the Evolution of Topics in Biomedical Informatics

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Abstract. Our study contributes to the history of international medical informatics through investigating the thematic evolution of the MEDINFO conferences during a period of consolidation and expansion of the discipline. The themes are examined and potential factors influencing the evolutionary developments are discussed.

Keywords. thematic evolution, biomedical informatics, MEDINFO conferences

1. Introduction

The history of sciences and technologies show a close connection between the evolution of different domains, especially in the case of inter-disciplinary fields [1]. The advent of computers stimulated pioneers in medical informatics, to propose new applications in biomedical research and clinical practice transforming healthcare worldwide over the past century. In this paper, we investigate the changes in topics of major interest to medical informatics through the lens of themes of papers published in key MEDINFO meetings (1986 to 2021) when the field was undergoing dramatic changes due to the advances in computational technologies such as the Internet and World Wide Web. Examining the context within which such changes occurred in biomedicine and healthcare allows a deeper understanding of how various scientific domains interweave, and can explain the evolutionary trends. In our approach, we started with the coalescing of the field noted in [2], adding the trends from the recent fifteen years and commenting on the new emerging topics emerging either due to developments in related fields or changing technologies and perspectives which resulted in cross-overs between the topics and changes in the themes that had been predominant earlier.

2. Background and Method

A major task of Scientific Committees of conferences is to allocate accepted papers into pre-defined thematic categories. The topics reflect to a reasonable extent the themes of major interest to the field at the time. During the early stages of the development of medical informatics the classification of the topics usually fell into two major taxonomic

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groups. There are those related to ***operations with information***: *Data:* types (numerical, signals, images), acquisition, storage (databases), retrieval, processing (biostatistics, signals and image analysis), protection; *Knowledge*: types, extraction (natural language processing, data mining, artificial intelligence), representation and use (decision support). These contrast to the group which emphasizes the scientific and healthcare technology disciplines for ***informatics application****:* molecular (bioinformatics), organ (imaging, sensors), patient (EHR, primary care, clinical informatics, nursing), community (hospital & health information systems, public health). Sometimes the thematic taxonomy would emphasize ***technologies or methods****:* new hardware (including interfaces, sensors, portable devices, telemedicine), tailored software (clinical, educational), specific processing methods (modeling and simulation, pattern recognition, imaging and others).

However, the theme of a paper is usually related to how it addresses readers' interests, defined by the potential impact of the work, the degree of novelty, cost-efficiency, regulatory/legal framework, potential risks, socio-economic-political context, accessibility, expected results, etc. So it is hardly surprising that themes and titles of the conference sections have changed, requiring reclassifications of papers into timely threads which cross over the original categories, as for instance, anticipating informatics for the 3rd millennium in 1998, usability and evaluation concerns in 2010, and increasing focus on quality, safety and outcomes in 2021.

The biggest problem was (and still is) that almost every paper could be allocated to several different topics or themes, since in an interdisciplinary field like medical informatics each can be categorized by methods, and contributions to specific biomedical and healthcare applications – for which the keywords in a paper can provide some guidance. the keywords). We have seen that from a *practical perspective there is no reasonable way to establish a crisp disjunctive list of non-overlapping topics for a conference*, highlighting the job of Scientific Program Committees (SPCs) is far from trivial. Reviewing the contents of MEDINFO Proceedings we have not noticed a coherently contextual taxonomy of topics along the years about the selection along a dominant taxonomic axis. The distribution of papers over sections also shows fairly high diversity, from a simple list of a couple of major topics up to a higher granularity - major themes, main topics and sub-topics, even classifications into various types – review, research, descriptive, opinion/vision or demos. Hence, from the very start, we were aware that the proportion of certain topics, as reflected in the contents can give only an approximate perspective on the changes of themes and topics in medical informatics.

We have considered four time points, somewhat more than a decade apart to enhance the detection of significant changes. The contents of four MEDINFO's conference proceedings from 1986, 1998, 2010 and 2021 have been reviewed [3,4, 5, 6]; in order to use relatively uniform time scale but also to examine how the careful work of the corresponding SPCs on paper classification based on topics, reflects a higher level of detail or granularity facilitating a clearer delineation of the major trends. The SPC of MEDINFO 86 [3] also correlated the major topics with the MeSH terminology.

The contents of these conferences were carefully analyzed, taking into account not only the initial allocation of a paper to a section, but also the title and the keywords, which were useful for re-allocating some papers which covered multi-topic themes (sometimes based on extra details from the paper itself), while trying to keep one paper in one category only; for instance, when a paper had a major topic to develop a software for a certain application, it was allocated to software, while when it was about the results of its application it was allocated to clinical applications; however, some papers met both conditions and it was allocated to both classes.

3. Results

Our results (Table 1) were obtained by redesigning Table 2 of [2] - redefining the topics with an increase in granularity, while adding papers from the 2010 and 2021 MEDINFOs.

Table 1. Full papers presented in selected MEDINFOs, by subject area.

		1986	**1998**	**2010**	**2021**
Total # of papers		277	263	260	204
Data	***ALL***	***96***	***89***	***108***	***34***
	Patient Record	12	27	17	12
	Data Bases	11	**	16	10
	Health Information Systems	43	19	60	
	Security	4	8	7	5
	Biosignals	7	3		
	Image processing	19	21	7	5
	Bioinformatics		11	1, *	2
Knowledge	***ALL***	***79***	***57***	***53***	***55***
	Knowledge extraction, Ontologies, Coding	20	22	35	24
	Information retrieval	7	10		
	Decision Support	47	25	15	12
	Artificial Intelligence	5		3	19
Technology, Infrastructure	***ALL***	***24***	***41***	***25***	***15***
	Hardware, Interfaces	16	11	6	11
	Software development	4		1, *	
	Telemedicine, Internet, mobile comm.		21	8	
	Standards, Interoperability		9	*	
	Advanced Methods, Simulation	4		10	4
Health & Clinical Applications and Management	***ALL***	***53***	***57***	***65***	***83***
	Clinical Applications, Workflow	26	17	11	32
	Organizational and Social Impact	4		*	16
	User Experience, Nursing Informatics	8	4	*	
	Health Policy, Ethics, Global Health	12	18	9	10
	Evaluation, Assessment, Quality	3	18	30	16
	Patient Empowerment, Consumer Inform.			15	9
Education	Education and Training - ***ALL***	***33***	***20***	***17***	***7***

* dedicated poster sessions on this topic

** an empty box did not mean that the topic was not present but that the papers were included in other topics.

4. Discussion

As mentioned above, the allocation of a paper to a category does not reflect its full covering of topical areas, since we have not focused on a precise percent for calculations of changes but mainly on the major trends, related to the interdisciplinary character of medical informatics. There are three main patterns of changes: topics which were of high interest initially but then diminished in interest, topics which showed an increasing interest, with some of them even occurring later, and topics which maintained a high level of interest over the years. One could possibly can add some topics which had a relatively short blossoming. Among the topics with a clear decreasing trend we can cite: specific software developments, bio-signal analysis and image processing to which we can add some topics with a slight decreasing trend: education, nursing informatics, even health information systems. The topics which showed an increasing interest are mostly those related to knowledge processing, with strong interest on artificial intelligence, but a decrease in decision support. Among the growing topics we note those related to the

challenges and impact of the new technologies and methodologies on all aspects of medicine and healthcare: evaluation, patient empowerment organizational and social impact, etc. It is very interesting to highlight the topics which have endured over the years. One of them is databases, which had high initial interest, followed by a decrease but with a strong comeback lately, related also to the "big data" trend, which actually brought to light new challenges – data quality, retrieval, curation, mining etc. –presenting many open problems and challenges yet. Another similar topic is the patient record; it is probably the most specific topic in medical informatics as the entry gate of "medical information as data"; showing how central the EHR is, requiring an entire system of great healthcare and economic impact, which explains the persistent interest in the topic.

We can list a series of factors influencing these trends: most of the initial work on signal and image processing or laboratory data emphasized the bioengineering methods, industry then solved most problems based on technological breakthroughs in informatics like CT imaging, while new analytical technologies like those from bioinformatics and digital data and knowledge bases with distributed online communications enabled the Human Genome Project and -omics translational medicine results. The Internet and World Wide Web led to semantic web capabilities which facilitate higher and higher performance for all levels of information systems. Most recently artificial intelligence methods have scaled up data-analysis and generative simulation capabilities which are frequently opaque and hard to understand, raising complex ethical and social challenges.

5. Conclusions

In general, explanations about the natural evolution of topics of interest in medical informatics coincide with our personal experiences over the years. However, we note two aspects that could be analyzed in greater detail. The first is about *whether a study or paper should be considered to really fit into the field of medical informatics*? For example, a clinical study that uses cytological images for diagnosis or statistical data processing is not likely to be classified as a cytology or biostatistics paper. Are clearer criteria needed? The second is related to the criteria for classifying the articles within conferences – a more painstaking classification task by the SPCs; would it be helpful to have *more appropriate sets of keywords to be extended* such that they clearly specify the type of technology/method used, application level or how well is the category addressed?

To conclude, as computational technologies achieve ever faster, and more efficient performance, human aspects and factors become even more prominent, critical for biomedical and healthcare informatics, which place its practitioners in responsible positions for designing technologies that will satisfy the Hippocratic responsibility, while implementing the best novel tools for clinical practitioners worldwide.

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