

Systematic Review of Robotics Use Since 2005

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Abstract—Robotics is one of the technologies used to design and operate robots. Currently, robots can be seen everywhere and in a variety of fields to obtain the most benefit from this technology; however, some fields may not be researched and studied as much as they should. Therefore, this paper presents a survey of the current studies on robotics from 2005 until now in order to find these fields. This paper finds that the aerospace, service, forestry, architectural, agricultural, and marine robotic fields have the least number of collected research papers, whereas the medical/healthcare has the most. This paper also provides some suggestions for each field; the one regarding the least researched fields is making more researches in these fields. Moreover, most papers do not discuss communication between robots, and have not made any real productions.

Index Terms—classifications of robotics, medical robots, robotics, systematic review

I. INTRODUCTION

Robotics is one of the technologies used to design and operate robots. Robots are machines programed by a computer to simulate humans, interact with them, and perform complex actions. Nowadays, robotics is growing drastically, as evidenced by the fact that we can find robots in any environment, for example, hospitals, schools, factories, and even homes [1].

For this reason, countless research on these fields has been published, and the number of papers in each field varies; some fields garner significant interest, whereas others garner less. Thus, the focus of this systematic review is to find the most current interesting field in robotics research; we found that the medical/healthcare field is the most researched, as explained later in this paper.

The world has benefited from robotics through various solutions, such as compensating for lack of manpower, increasing work efficiency, reducing production costs, and many others. Thus, it is important to determine the field least researched in order to continue improving robotics benefits.

Most current robotics papers are on each individual field, and discuss and review those fields' robots. None have published or studied the gaps among these fields, or determined those that are the least researched.

Therefore, this paper aims to find the intended purpose discussed earlier. In addition, to the best of our knowledge, there has not been any other systematic review specific to robotics research. In this paper, we classify English academic papers related to robotics using a systematic review, and answer these questions:

- What are the application types in robotics from 2005 until now?
- What is the distribution of the publications on robotics?
- What are the fields of the robotics research papers?
- What are the characteristics and status of the current research on robotics?

This paper is organized in two parts. The first part discusses the methods for data collection and selection criteria, as well as data classification and analysis. The second part answers the aforementioned research questions and discusses the study limitations.

II. METHOD

A. Data Collection and Selection Criteria

Robotics has been researched in many fields and for different years; however, we opted to collect English academic papers published in journals, conferences, and book chapters. In addition, we selected papers with a research focus on robotics, and excluded papers published before 2005. In order to choose any paper, we reviewed the paper briefly, and read the title and abstract carefully.

To search and collect the papers for this study, we employed the keywords "robotics in healthcare/education/industry." Moreover, we conducted our search using the databases IEEE Xplorer, Springer Link, ACM, Science Direct, Nejm, Science, Wiley, Emerald insight, and Europepmc. Table I lists the results the searched databases (we found 59 papers in total).

We searched for some of the major fields in robotics research. For this, we analyzed previous and current researched papers, and obtained the main fields in current robotics research.

TABLE I. SEARCH RESULTS – SELECTED ACADEMIC DATABASES

Database	Relevant Search Result
IEEE Xplorer	36
Springer	12
Others	6
ACM	3
Science Direct	2

B. Data Classification and Analysis

To classify and analyze the data, we performed the following steps:

First, we collected data from different resources to analyze them and reproduce some beneficial information. Next, we used the year of publication, type, authors, citation number, database, and title as factors to classify the collected papers.

1) Quantitative analysis

As shown in Fig. 1, the number of publications vacillates from 2005 to 2008, and then increases suddenly in 2009; subsequently, the number decreases. Fig. 2 shows that the most common form of publication is in journals and magazines (33), followed by conferences (23), and books (3).

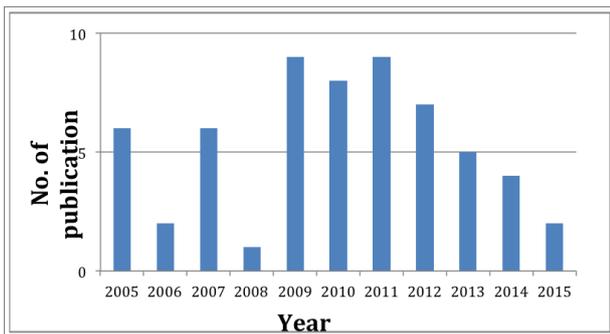


Figure 1. Papers by publication year

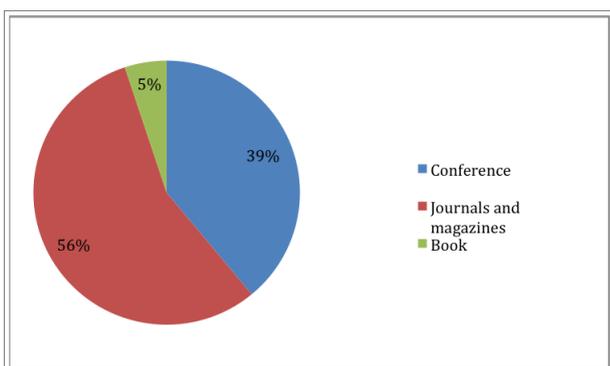


Figure 2. Type of publication

As seen in Fig. 1, the total number of papers published in 2009 and 2011 was nine, which is the highest number from 2005 to 2015. Obviously, the number has decreased since then to two papers from the total of 59 in all ten years. The reason for such reduction could be the fast development of robotics or the researchers’ decreased interest in the field.

In addition, Table II shows the most cited papers according to Google Scholar. Clearly, all such papers

were published between 2005 and 2010. Moreover, the most cited paper is “New Technology and Health Care Costs—The Case of Robot-Assisted Surgery” [2] with 353 citations in 2010 in the medical/surgical field. This is followed by “Defining Socially Assistive Robotics” [3] with 251 citations in 2005. Next is “From Swarm Intelligence to Swarm Robotics” [4] with 226 citations, also in 2005. Two years later, “The Evolution of Robotics Research” [5] was published, and it was cited 152 times. In the same year, “Present and Future Robot Control Development—An Industrial Perspective” [6] was published for the industry field, and it was cited 144 times. Two years later, “Acceptance of Healthcare Robots for the Older Population: Review and Future Directions” [7] was published, and it was cited 135 times. The next most commonly cited paper, with 109 citations, was published in 2007: “How Social Robots Will Help Us to Diagnose, Treat, and Understand Autism” [8]. Finally, the last paper in the list of most cited papers is “The Educational Use of Home Robots for Children” [9], which was published in 2005 and cited 106 times.

TABLE II. MOST CITED PUBLISHED PAPERS

Paper Title	No. Of Citations	Published Year
New Technology and Health Care Costs—The Case of Robot-Assisted Surgery	353	2010
Defining Socially Assistive Robotics	251	2005
From Swarm Intelligence to Swarm Robotics	226	2005
The Evolution of Robotics Research	152	2007
Present and Future Robot Control Development—An Industrial Perspective	144	2007
Acceptance of Healthcare Robots for the Older Population: Review and Future Directions	135	2009
How Social Robots will Help Us to Diagnose, Treat, and Understand Autism	109	2007
The Educational Use of Home Robots for Children	106	2005

Besides, Table III shows the most three active robotics authors. E. Broadbent and B. MacDonald have five papers each, and R. Stafford has three. All the three authors share the same articles, which means that there are more than 44 different authors writes and research on robotics, while no one stand out the most.

2) Publications' application fields

This systematic review includes the different fields that are related to robotics since 2005. There are various types of robotics for each field. We categorized the papers we found into the following types of robotics: medical/healthcare, industrial, social/personal/home,

aerospace, architectural, marine, forestry, educational, agricultural, and service. Furthermore, we grouped these papers based on the year of publication from 2005 to 2015, as indicated in Table IV. It should be noted that some papers discuss multiple types of robotics. Consequently, the total number of assigned papers is higher than 59 in Table IV.

TABLE III. MOST ACTIVE AUTHORS

Author	No. of Papers	Paper Title
Elizabeth Broadbent	5	The Role of Healthcare Robots for Older People at Home: A Review
		Age and gender factors in user acceptance of healthcare robots
		Deployment of a service robot to help older people
		Attitudes towards health-care robots in a retirement village
		Acceptance of Healthcare Robots for the Older Population: Review and Future Directions
Bruce Alexander MacDonald	5	The Role of Healthcare Robots for Older People at Home: A Review
		Age and gender factors in user acceptance of healthcare robots
		Deployment of a service robot to help older people
		Attitudes towards health-care robots in a retirement village
		Acceptance of Healthcare Robots for the Older Population: Review and Future Directions
Rebecca Stafford	3	Age and gender factors in user acceptance of healthcare robots
		Deployment of a service robot to help older people
		Acceptance of Healthcare Robots for the Older Population: Review and Future Directions

TABLE IV. PUBLICATION CATEGORIES ACCORDING TO FIELD

Paper Field	# Of Assigned Papers
Medical/healthcare Robotics	27(45%)
Industrial Robotics	16(26.6%)
Educational Robotics	8(13.3%)
Social/personal/home/workplace Robotics	7(11.8%)
Aerospace Robotics	3(5%)
Service Robotics	3(5%)
Forestry Robotics	1(1.6%)
Architectural Robotics	1(1.6%)
Agricultural Robotics	1(1.6%)
Marine Robotics	1(1.6%)

III. DISCUSSION AND LIMITATIONS

In this section, we discuss the results that answer the research questions posed in the Introduction.

The purpose of our research is to find those gaps where there is less interest in a specific field of robotics research. In this paper, we collected data from different resources to find a number of research fields in robotics. Medical/healthcare, industrial, educational, social/personal/ home/ workplace, aerospace, service, architectural, agricultural, marine, and forestry robotics are the fields that we found, and we discuss this next.

In medical/healthcare robotics, there are various types that can be classified further, for example, surgical, diagnosis, nursing, etc. Therefore, we found that most papers show interest in surgical and diagnosis, and neglect the other classifications, which are equally important. Speed of development in the field of healthcare and medicine; furthermore, medical robots can make fundamental changes in operations, behavior, and diagnosis. The main reason for the research in this field is to improve robots in medicine and healthcare in order to protect human life, which is very important, and to improve life for humanity.

The next field in which researchers are interested is industrial robotics, where the most robots are employed [1]. Unlike medical/healthcare robotics, the industrial field does not have different types of robotics. However, the majority of collected papers discuss the robot industry in general. Therefore, the finding here is that papers do not report on the robots that work in industrial environments; there is no demand for industrial robots, and the U.S government does not perform sufficient work to fund these robots. They found that, if there is no one to guide these industry robots, then it will not be organized, thus resulting in a waste of time and money.

In educational robotics, most papers are experiments for allowing robots to teach in schools. However, we could not find research that described how these robots are trained to teach, or how to make a robot be dedicated to a specific subject. By knowing this information, it should be possible to know how to train and adapt the robots to a specific type of special needs, or be used as independent homeschool teachers. However, how can these robotic tutors manage student questions and bidirectional dialogue? Consequently, we found that more research is required in these topics.

Most papers related to social areas, such as personal, home, and workplace robotics focus on physical and nonphysical interactions between humans and robots. However, the papers do not discuss interaction between robots in the case of having two or more robots in the same place. For example, an elderly couple lives in the same house, both have medical needs, and each person requires a type of personal robot. How would each robot act with regard to the existence of the other? On the other hand, we know that these robots are made to help people, especially elderly individuals, but they are very expensive.

Finally, the aerospace, service, forestry, architectural, agricultural, and marine robotics have the least number of collected research papers. Therefore, we suggest conducting more studies in these fields, or any field not included in our paper. In general, the most noticeable aspect is that there are many published papers, but almost no hard evidence on the global economic impact of robots [10]. In addition, the number of papers that discuss robots are logically programmed is limited compared with the number of papers that describe experiments with them in real life.

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