A Systematic Mapping Study on Touch Classification

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Summary
One of the basic interpersonal methods to communicate emotions is through touch. Social touch classification is one of the leading research which has great potential for more improvement. Social touch classification can be beneficial in the much scientific application such as robotics, human-robot interaction, etc.. Each person has the ability to interact with the environment and with other people via touch sensors that are speared over human soma. These touch sensors provide us with the important information about objects such as size, shape, position, surface and their movement. Therefore, the touch system plays the main role in human life from early days. The small gesture can express strong emotion, from the comforting experience of being touched by one's spouse, to the discomfort caused by a touch from a stranger.
This paper presents and explains a systematic mapping study on social touch gesture recognition. From various digital libraries, 938 papers in total are collected. After applying three filters, 49 papers as primary studies related to the main topic are selected as listed in Appendix (A). The selected papers classified with respect to several facets. The results provide an overview of the existing relevant studies that are reported in the literature, highlight the focused areas and research gaps.
Key words:
Systematic mapping studies; Systematic Reviews; Evidence Based on Human-Robot Interaction.

1. Introduction

The essential purpose of nonverbal (touch) is to communicate and transfer emotions between humans. So, sometimes the social touch is used to express the human state or it is used to interact with human and animal or robot [1]. Touch is used by people as a powerful method for social interaction. People via touch can express a lot of positive and negative emotions such as (dis) agreement, appreciation, interest, intent, understanding, affection, caring, support and comforting between them [2-4]. Different types of touches give different messages, for example, handshake used for greeting, slap for punishment, petting is a calming gesture for both the person and animal doing the petting, and reduce stress levels and evoke social responses from people[2, 5, 6].
The study of social touch recognition depends on the idea of the human ability to communicate emotions between them via touch. To help the robot to interpret and understand the human gestures through interaction with the human, the gesture patterns must be recognized in a correct form[7-9]. The precise recognition spurs robot to respond to human and express it is internal state and artificial emotions in positive action. Therefore robots must be equipped with some sensor devices that have the ability to elicit emotions and facial expressions similar to human behavior [2, 6]. We can develop the system for touch recognition by two methods: touch-pattern-based design (top-down approach) and touch-receptor-based design (bottom-up approach)[10].
To make the robot partnership with the society and interact with human as effective manner, we must prepare the critical requirement such as a reliable method for control, perception, ways of learning and response as correct emotion. Touch sensing in humanoid robots may help in understanding the interaction behaviors of a real-world object. The most significant and critical issue with the designing of social robotic, is how to learn it during interaction with users, make it has the ability to store past participation and use this information from what has happened when its response to human[2, 11, 12].
There are a lot of techniques developed but nobody summarized them before. This paper explains systematic mapping study process steps on social touch gesture recognition. At the same time, it provides a good summary to the researchers who may perform a future research on the social touch gesture recognition. In addition, it identifies the fundamental goals and research questions that we depend on it to collect articles and we determined the screening methods of papers [13]. It provides answers to some questions related to this topic. A systematic mapping study provides a structure of the type of research reports and results that have been published by categorizing them [14]. It permits the evidence in a field to be plotted at a good level of granularity. It often considered as a visual summary, the map, of its results, it can the more coarse-grained overview with fewer efforts.
The remainder of this paper is organized as follows: Section 2, presents literature review protocol. Section 3, describes the screening of the papers. Section 4, explain how to build different viewpoints using a variety of schemes. Section 5, explains classification schemes and Section 6, includes a list of conclusions.

Manuscript received March 5, 2018
Manuscript revised March 20, 2018

2. Literature Review Protocol

In this section, we will explain the steps of systematic mapping study on the social touch recognition.

2.1 Research Questions

The main purpose of the systematic mapping studies is to help researchers to get a clear overview of the selected study area. To get to overview which satisfies quantity and type of research result with available its contribution. We must identify set of research questions (RQs) [13]. The research questions must be defined carefully for each selected study. These questions extracted depend on articles titles and the relevant studies [14, 15]. The results obtained from this process help the researchers in the specific field to get access to the required information as quickly as possible. For example, when researchers need to map the publication frequencies per years to identify the studies trends, and another researcher can identify the forums in which research in the specific area has been published [13]. In this case, each one can obtain the information he/she wants. The number of research questions and its formula different from study to another. The research questions for social touch gesture recognition shown in Table 1. We can define the questions as follows:

Question 1: This type of questions identify various methods and algorithms that used to obtain different results.

Question 2: This type of questions used to determine the main factors and variables that affect the study results.

Question 3: By this type of questions we can get on different ensors and interfaces used.

Question 4: This type of questions helps the researchers to determine the future work that used to improve research result.

Table 1: Research questions for social touch gesture recognition.

RQ 1: Which are methods used to recognize the social touch gesture?
RQ 2: What are the factors that effect on accuracy of classification ratio?
RQ 3: What are the types of artificial skin interface and sensors used to sense the touch gesture?
RQ 4: How to improve classification ratio of the social touch gesture recognition?

2.2 Keywords and Search String

2.2.1 Identify Keywords

Social touch; Touch gesture recognition; Touch sensing; Human-Robot Interaction (HRI); Touch Features; Touch corpus; Humanoid robots; Touch sensing system; Affective touch; Artificial sensitive skin; Emotional touch pattern; Robot Pets.

2.2.2 Search String

We can use research questions and keywords which obtained from previous sections to create the effective structure of search string. The number of papers and its relevance to our research study depends on the selection of suitable keywords [16]. By using search string in various search engines via Word Wide Webs such as digital libraries and scientific databases or manually searching in relevant conference proceedings, journals and workshop publications, we can identify primary studies. To get on the best form of the searching string, we must put them in comparison, publications and interventions [17, 18]. So the search string for "social touch gesture recognition" can be written as illustrated in Table 2.

Table 2: Search string for human –robot interaction

("touch" OR "social touch" OR "gesture " OR "affective touch" OR "tactile" OR "haptic" OR "emotional touch") AND ("classification" OR "recognition" OR "interaction" OR "detecting" OR "sensing" OR "feature ") AND ("ratio" OR "accuracy" OR "performance" OR "efficiency")

2.2.3 Search strategy

After we are created search string, now we can use it to gather the relevant studies from different digital databases. A lot of digital libraries around the world, we can depend on it to provide the required data. During the searching process, we will try to collect a large number of relevant studies as possible as we can. Two types of search methods depend on the way used to collect studies. First one called automatic search, we can be used it to search ACM digital library, IEEE explorer, Springer link, Digital Bibliography & Library Project(DBLP). The second type is called manually where this method used to search for journals, conferences, and workshops as they have extensive information [13-16]. In this paper after three refinements, we got on results from publication venues, as shown in Table 3.

Table 3: Publication venues

Digital Library	#of Papers
IEEE explorer	20
ACM Digital Library	13
Springer Ling	7
Scopus Library	3
Digital Bibliography & Library Pro	2
Elsevier Library	1
Human-Computer-Interaction (HCI	1
Child Neuropsychology	1
International Journal of Robotic F	1
Total	49

3. Screening of the Selected Papers

The screening steps are applied to all collected papers to get rid of all papers that irrelevant to our study. There are two essential criteria used to perform this task (Inclusion & Exclusion). Inclusion used to include all papers that are related to our search depend on some aspects. While Exclusion eliminates all papers which out of our search [13, 19]. In some time the process of papers screening or stage repeated multi times to get into the final decision. Each stage is stricter than the previous stage, to get on the number of papers that has the proper answer to our research questions [13, 14]. Fig. 1, illustrates the stages that implemented to complete systematic mapping. For our study (social touch gesture recognition) first attempt we have collected a total of 938 articles at primary research. However, the articles were maxed from (books, papers, report workshop, lectures, power point presentations, and others etc..), published from 1996 to 2017. The process of papers screening pass through three filters each one eliminates the set of irrelevant papers. The first filter reduces the papers to 532 papers depends only on the type of article. The second filter was more rigorously from the first one which eliminates papers to 108 depending on (title, keywords, and abstract) of papers. The last filter includes 49 papers only depending on papers contents.

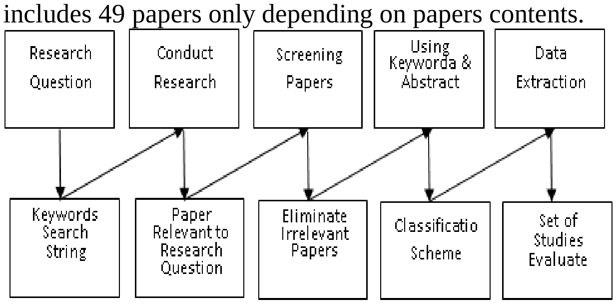

Fig. 1 Stage of systematic mapping study

3.1 Inclusion Criteria

Inclusion criteria kept and included all relevant papers that satisfy the inclusions conditions related to our study (social touch gesture recognition). The papers that included such as journals, conferences, technical report, and workshops. In addition to these papers, we also included the papers which related to our study from other aspects such as interface or touch surface, the type of sensors used to sense the touch, design the system for recognition (between human and robot, between two subjects), type of gestures. During the reading of the article title, we must check the answer to everything related to the topic. Because the classification process depends on this papers information [15, 18].

3.2 Exclusion Criteria

Exclusion process as opposed to the inclusion process, where we eliminate all papers that are not related to our study (social touch gesture recognition). Eliminate articles such as books, titles that are not written in English language, incomplete papers, power point presentations, short papers less than 2 pages, duplicated papers (papers that exit in journal and conference), posters and advertisements, papers that are available as abstract only, and reports that unreal output for our research. The researchers may determine the period of time for his study and eliminate all papers outside of this period [14, 19].

4. Building Different Viewpoint using A variety of Schemes

Different viewpoints provide researchers and readers with significant information about him/her subject. Different schemes give different views and defining comprehensive information of articles on any topic that we deal with. Fig. 2, explains the distribution of the number of primary studies per years. While the Fig. 3, shows the distribution of papers according to venue chart, where the paper is split into conference, journal, and workshop.

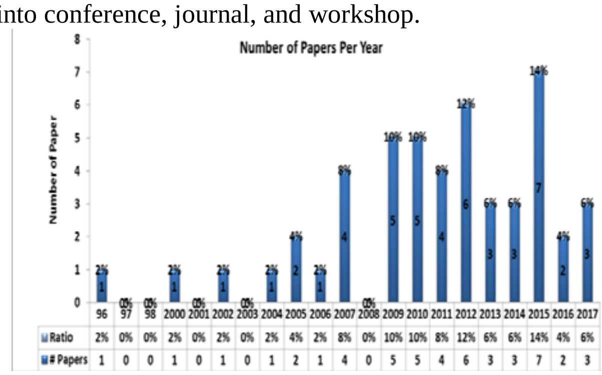

Fig. 2 Distribution the papers per years.

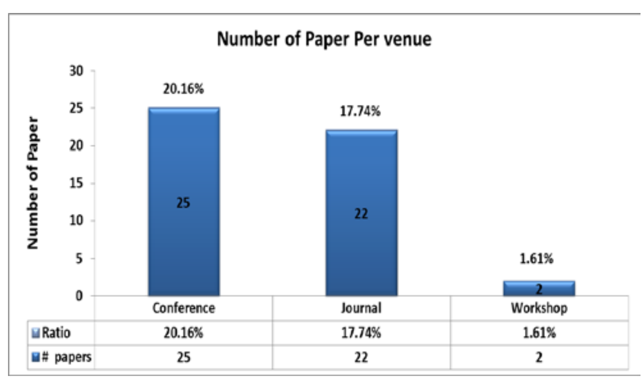

Fig. 3 Distribution of papers per venue.

5. Classification Scheme

In classification scheme, we will plot selected papers in different facets. The number and type of facets are selected to cover all attributes and factors that effect on study subject. Therefore each research topic has specific facets identified by authors. In these papers we are classified collected papers into five different facets which consist of following type.

5.1 Research Type Facet

Classified papers according to (Validation Research: techniques that used for example experiments ant not yet run in practice, Evaluation Research: evaluate the techniques that practice implemented and determine the advantage and disadvantage of this technique, Solution Proposal: find solution for the existing problem, the solution of this problem may be novel or an improvement of existing method, Philosophical Papers: map a new approach of looking at existing work form of a taxonomy or conceptual framework, Opinion Papers: depend on personal opinion don't rely on the related work to evaluate specific technique that is good or not, Experience papers explains what and how something has been done in practice. It has to be the personal experience of the author.). Fig. 4, Shows the research type facet.

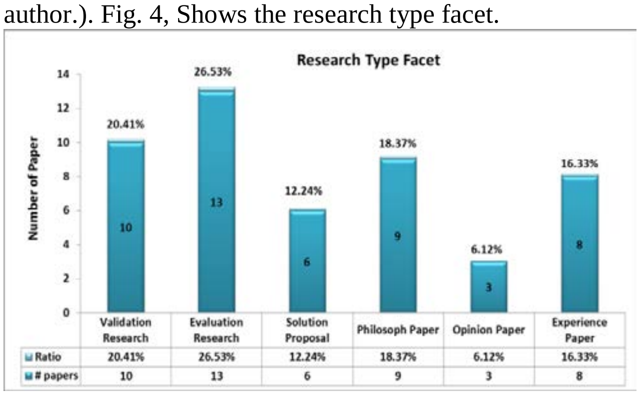

Fig. 4 Distribution of studies based on research type.

5.2 Classification Method Facet

It divided papers according to methods and algorithms used to recognize or classify social touch gesture. Fig. 5, illustrate this facet where the method that used consists of (Support Vector Machine "SVM", Neural Network "NN", Random Forests "RF", Bayesian Classifier "BC", Deep Autoencoder "DA", Logistic Regression "LR", K-Nearest Neighbor "KNN", Hidden Markov Model "HMM", AdaBoost "AB", Finite State Machine "FSM", Convolution Neural Network "KNN", and other).

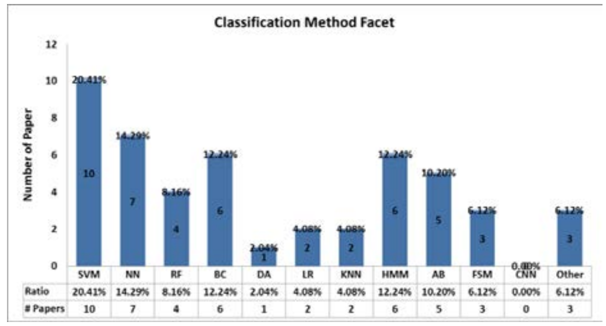

Fig. 5 Distribution of studies based on classification methos.

5.3 Touch Surface Facet

In this facet, we are divided papers according to the robot form that used as the interface between human and machines. This facet includes (Haptic creature, Humanoid robot, Furry lab pet, Fur sensor, Mannequin arm, Camera image). Fig. 6, explains divided paper on this touch surfaces.

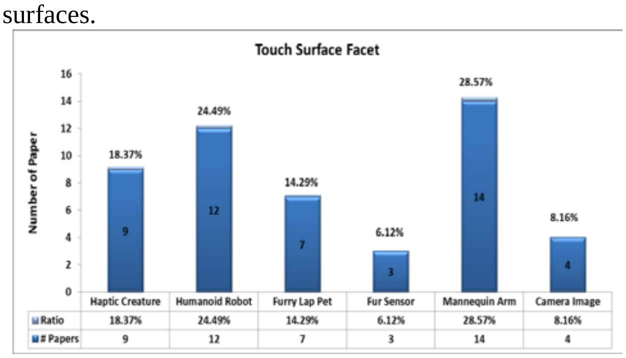

Fig. 6 Distribution of studies based on touch surface.

5.4 Sensor Type Facet

Here we are divided studies according to sensors that used to recognize the gesture. The sensors include (Force sensing resistor, Accelerometer, Microsoft Kinect, Conductive fur sensor, Pressure sensor, Conductive ink, and Other). Fig. 7, explain plot papers depend on the sensor used.

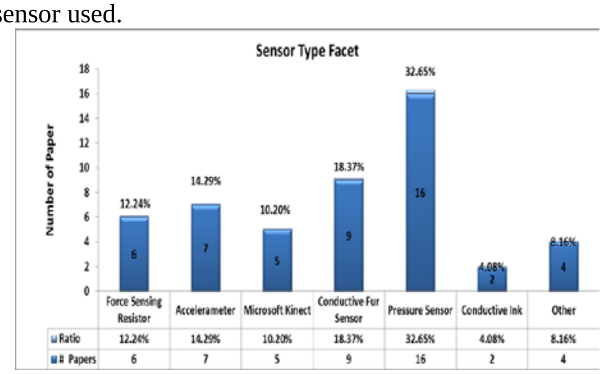

Fig. 7 Distribution of studies based on sensor type.

5.5 Touch Recognition of Facet

In this facet, we have divided papers according to the touch type such as (Gesture, Emotion, Full body gesture, Part body gesture, and Social massage). Fig. 8. Explain how papers plot according to touch type.
To get more significant information about our study we plot bubble chart. It is two x-y figure plot bubbles of two or more intersection facets. Where the size of the bubble depends on the number of articles which appear on the bubble. Bubble plot supports the researchers with summary statistic and the quick overview of the field that can be added for facets individually [14, 15, 19]. Fig. 9, represents bubble plot for sensor type facet with the touch surface. While Fig. 10, represents bubble plot of research type with the classification methods.

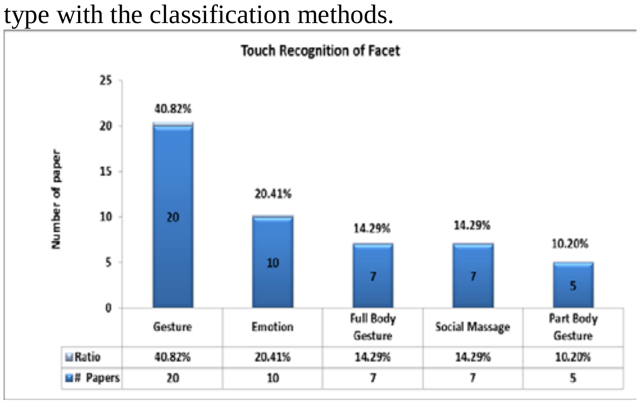

Fig. 8 Distribution of studies based on touch recognition of.

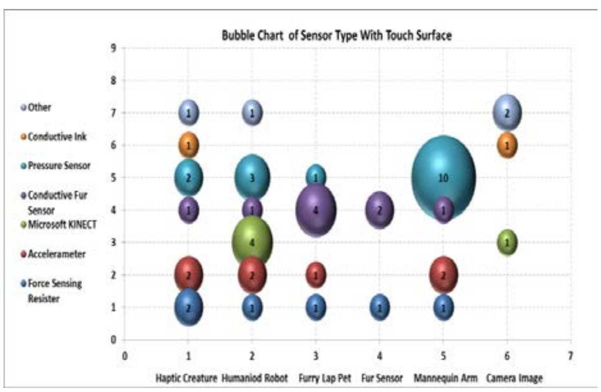

Fig. 9 Bubble plot of studies based on sensor type and touch surface.

6. Conclusion

In this paper, we performed systematic mapping study for social touch gesture recognition. The first steps in the systematic mapping study for any scientific researchers which have a significant effect on the study results are the number and type of research questions, keywords, and search string. These three factors helped researchers to get into articles related to him/her topic. Therefore, the researchers were responsible for identifying this set of factors. Which helped them to reach the required information as quickly as possible. The research field determines the selected questions. For example, some questions asked to determine the target for analysis and tools. Other questions selected to determine the properties, performance, and activities that satisfy this research. Sometimes the searcher depends on a standard form of questions, mechanism, and criteria to search for the required studies. In some studies the researchers want to know the application of research or does it satisfy its target. The experimental search used for this task. The questions used to search for different opinions about studies and scientific analysis represent the most important type of questions. So we must identify the best questions, which helped them to get on results in particular field. All details and relevant factors that effect on result must be taken into consideration.
In this paper after we eliminated irrelevant papers and distributed the remaining 49 papers over the years ranged from 1996 to 2017, we can notice that most papers were published during 2015. While the distributed papers per venues explain that most papers were published in conferences. We had used several facets to distribute papers. These facets include (research type, classification methods, touch surface, sensor type, touch recognition of). From research type facet we can notice that most papers are put into evaluation papers and validation papers. The classification methods facet explains that the Support Vector Machine method was used in most publications. From the touch type facet, we can notice that the mannequin arm type was used more than other touch types. From sensor type facet we concluded that the pressure sensor is used in most of the studies. The touch recognition of facet explains the gesture recognition that used in most of the studies. Finally, we plot bubble chart between research type facet and classification methods facet. From this plot, we noticed that all previous studies didn't use the convolutional neural network for social touch recognition. While the second bubble was a plot between sensor type facet and touch surface, and we can conclude that most studies used the pressure sensor and mannequin arm at the same time.

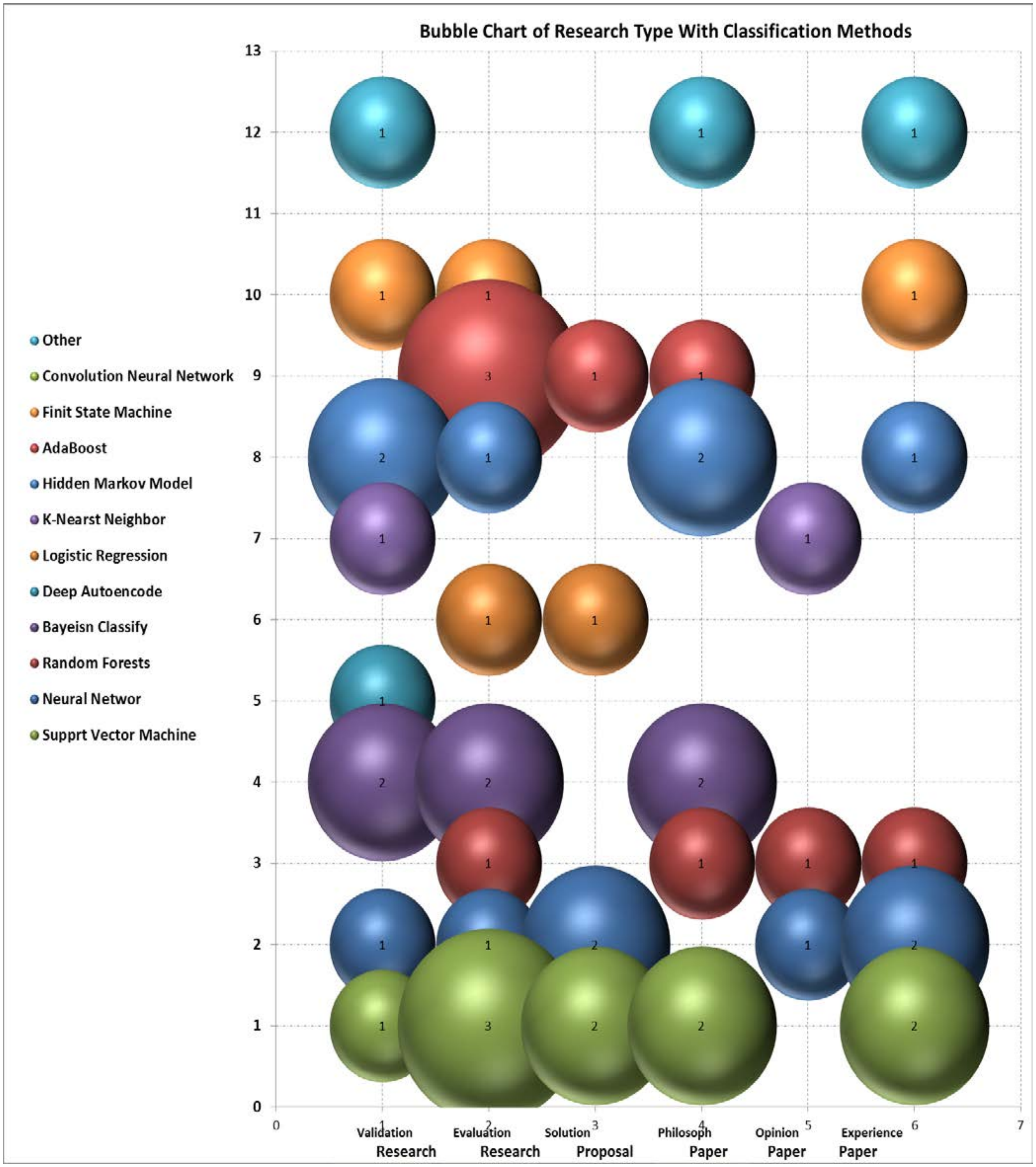

Fig. 10 Bubble plot of studies based on research type and classification methods

Appendix A

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