Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 4 Issue 8, August - 2017

Systematic Mapping Of Algorithms Used In Mammographic Image Processing

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Abstract - Computer science applied to medicine has acquired an important role, along with the use of artificial intelligence techniques. In particular, Knowledge Engineering in Oncology, requires a more thorough, impartial and systematic mapping of the progress in this area. For this purpose, systematic mapping of algorithms used in stages of mamographic image processing was constructed, starting from a search in the Web of Science, Engineering Village and Scopus databases. Evidence was sought and requirements in the area were met. A strict selection was carried out by three specialists in image processing. Fourteen out of 199 articles retrieved from databases were accepted. Consolidated analyses of the 14 accepted articles were conducted for the construction of the systematic study proposed.

Keywords: Breast cancer; mass detection; mammographic images; texture feature extraction; neural networks.

I. INTRODUCTION

Systematic mapping is a form of literature review, where a broader review of primary studies is carried out. In this review, a search is carried out to identify which evidence is available, gaps in the group of primary studies where future systematic reviews are focused and areas where more primary studies need to be conducted [9].

According to Bailey et al [3], systematic mapping is frequently used in medical research. Nevertheless, it has been neglected in Software Engineering. In brief, systematic mapping may be understood as a modality of research with the same initial stages and formalities as a literature review. However, systematic mapping contains a broader and more general research question, due to its exploratory purpose [7,8]. Throughout the years and with the dissemination of literature reviews in Software Engineering, systematic mapping in medical research has gained an increasingly more significant role. Zhang and Ali Babar [24] emphasized that systematic mapping studies have achieved considerable growth in recent years.

Systematic mapping is generally composed of three stages. The first stage consists in the identication of

primary studies that may contain relevant research results. In the second stage, appropriate primary studies are selected from the studies identied, to find those studies that will need a further and deeper analysis. In the third stage, quality assessment of the studies selected in the second stage is performed. In a systematic review, the stages described would be followed by data extraction and data analysis [9].

It has been presumed that one of the most complex tasks in systematic mapping is the creation of a model representing knowledge in a certain area of interest. Therefore, this article proposes to study existing techniques and tools in the area of image processing for mammography using artificial neural networks.

II. MATERIALS AND METHODS

In compliance with methodological procedures, we carried out a search in the Web of Science, Engineering Village and Scopus database, from June to September 2016. Systematic mapping study was performed using a quantitative approach based on the analysis of the amount of articles with keywords, abstracts and titles related to the development of software as a tool for tumor detection in mammographic images using artificial neural networks.

A search in the database returned 200 articles published from 2004 to 2016 that were related to strings of mamographic images and neural networks. A file in BibTex format was generated from the database search, which was submitted to the TheEnd - Systematic Mapping Tool, available at http://easii.ufpi.br/theend/home, for construction of the Systematic Mapping study proposed, in the following stages.

I. Planning

a. Objective: Identify algorithms and training tecniques for machine learning, used in image processing stages for tumor detection in mammograms.

b. Research Questions

i. Which algorithms are most widely used for image segmentation;

ii. Which algorithms are the most widely used for image feature extraction;

iii. iii. Which supervised learning classifiers stand out in the classification of mammography tumors.

II. Search strings: The construction of search strings used in the digital libraries selected, followed the strategy defined by Kitchenham (2006) which identifies the main keywords from research questions, and uses the connector word ‘OR’ to match synonyms and alternative terms of each keyword and the conector word ‘AND’ to match keywords. The search strings used were: mamographic images and neural networks.

III. Criteria for inclusion and exclusion: The criterion was based on relevance relative to investigated questions.

a. Inclusion: Mass detection; mammographic images; texture feature extraction and neural networks.

b. Exclusion: microcalcifications and ultrasonography.

III. RESULTS

A search was conducted in the Web of Science, Engineering Village and Scopus databases and returned 200 articles, according to Figure 1.

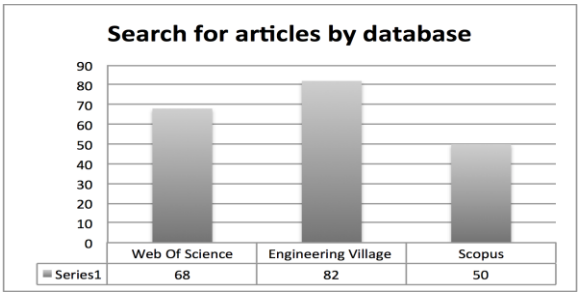

Figure 1. Articles obtained by database search

In the refinement step of search results, a repeat file was found and excluded from mapping, remaining 199 articles to be assessed by three specialists in the field of image processing.

Following criteria used for inclusion and exclusion, the evaluators read all the abstracts of articles, aimed at selecting content that was relevant to mapping, resulting in 185 rejected articles and 14 accepted articles. After the evaluation stage, it could be perceived that there were few articles published on the topic from 2004 to 2015. There were about two publications in the years 2004, 2008, 2010 and 2015. A significant increase occurred in 2016, as shown in Figure 2.

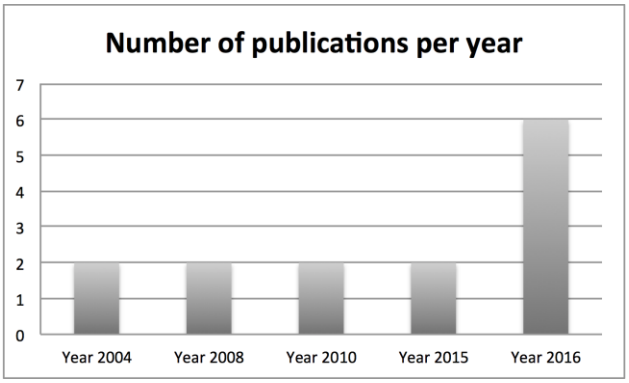

Figure 2. Publications per year.

Among 14 accepted articles, we observed that algorithms of K-means clustering, Template Matching technique, Otsu method (OTSU, 1979) and PSO (Particle Swarm Opitimization) method, were the most widely used algorithms for segmentation of suspicious breast regions, as shown in Figure 3.

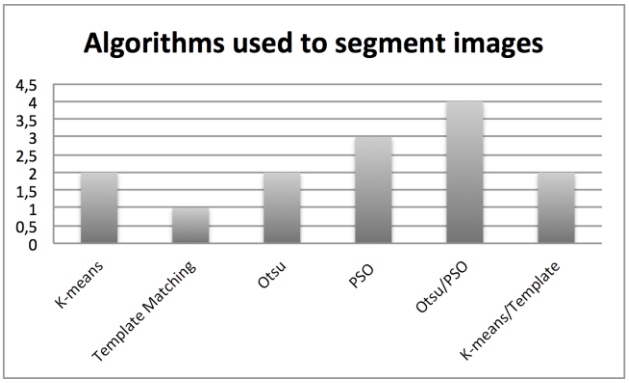

Figure 3. Most widely used algorithms in image segmentation.

In the stage of image feature extraction among the articles accepted, the Haralick, Local Phase Quantization and Local Binary Pattern algorithms stood out, as shown in Figure 4.

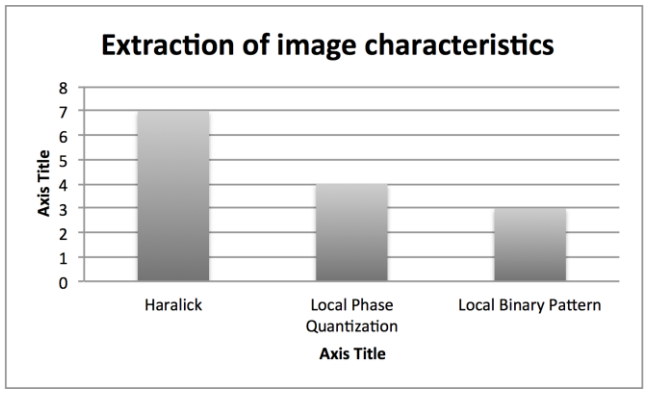

Figure 4. Algorithms used in image feature extraction

According to the articles, the best classifiers by learning supervision that produces the best performance were Random Forest, Multi-Layer Perceptron, Support Vector Machines, Radial-Basis Function Networks and Naive Bayes algorithms. Algorithms of Support Vector Machines and Random Forests used in 5 and 4 studies, respectively, were highlighted in the articles accepted, as shown in Figure 5.

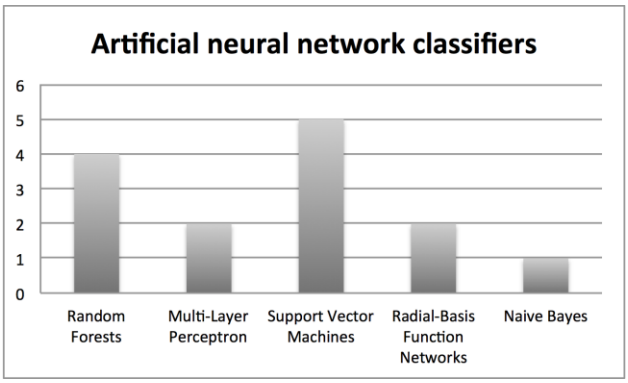

Figure 5. Classifiers of artificial neural networks

IV. CONCLUSION

The results of this research presented systematic mapping. The aim of systematic mapping is to find mechanisms to guide empirical studies on mammographic image processing using artificial neural networks. After careful analysis by three specialists in

image processing, 14 articles out of a group of 199 articles analyzed were considered relevant to mapping. From the articles selected, hypotheses were formulated to investigate which algorithms were more widely used for segmentation and feature extraction. Algorithms that achieved the best performance as classifiers in artificial neural networks applied in mammographic image processing were also investigated. Otsu and PSO algorithms stood out in the segmentation stage, and were used in 4 out of 14 accepted articles. During the stage of feature extraction, the Haralick algorithm stood out and was used in 7 out of 14 publications. The best classifier for learning supervision it was the algorithm Support Vector Machines, highlighted in 5 out of 14 accepted articles.

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