



An expert system for selecting wart treatment method



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ABSTRACT

As benign tumors, warts are made through the mediation of Human Papillomavirus (HPV) and may grow on all parts of body, especially hands and feet. There are several treatment methods for this illness. However, none of them can heal all patients. Consequently, physicians are looking for more effective and customized treatments for each patient. They are endeavoring to discover which treatments have better impacts on a particular patient. The aim of this study is to identify the appropriate treatment for two common types of warts (plantar and common) and to predict the responses of two of the best methods (immunotherapy and cryotherapy) to the treatment. As an original work, the study was conducted on 180 patients, with plantar and common warts, who had referred to the dermatology clinic of Ghaem Hospital, Mashhad, Iran. In this study, 90 patients were treated by cryotherapy method with liquid nitrogen and 90 patients with immunotherapy method. The selection of the treatment method was made randomly. A fuzzy logic rule-based system was proposed and implemented to predict the responses to the treatment method. It was observed that the prediction accuracy of immunotherapy and cryotherapy methods was 83.33% and 80.7%, respectively. According to the results obtained, the benefits of this expert system are multifold: assisting physicians in selecting the best treatment method, saving time for patients, reducing the treatment cost, and improving the quality of treatment.

1. Introduction

Machine learning and data mining algorithms are utilized to analyze large datasets and discover and extract knowledge from them. They are also employed as a tool in medical sciences [1–18], crime detection, risk assessment, and sales of products. These algorithms can analyze data in order to discover the unknown patterns in large databases. Industries such as banking, insurance, health, and marketing commonly apply them in order to reduce costs, improve the quality of research, and increase the amount of sales.

Classification is one of the important tasks in machine learning and data mining. Fuzzy rule-based systems have recently been employed for classification [19–23] to handle the concept of partial truth. Truth values may range between *completely false* and *completely true* [24].

Fuzzy rule-based systems are applied in many different fields, including artificial intelligence, control theory [25] and medical fields. In the medical field, they are utilized for the early diagnosis of diseases and important factors influencing them [12,13].

In medical research, one of the most important fields is skin disease, and among the skin diseases, researchers generally apply machine-learning methods to Melanoma treatment [26–40]. Melanoma is a type of skin cancer developing from melanocytes which is a type of pigment-containing cells [41].

A number of studies have been performed on other skin diseases, using machine-learning algorithms [42–45]. However, as far as we know, there has been no machine-learning research conducted in the field of wart treatment thus far. Although there are different wart treatment methods [46], physicians have not recognized which one is more effective for each patient. They are obliged to test each method individually.

In this research, we investigated immunotherapy with candida antigen and cryotherapy with liquid nitrogen on 180 patients with plantar and common warts [46] who had referred to the dermatology clinic of Ghaem Hospital, Mashhad, Iran. These two treatment methods were selected as they are two of the best wart treatment methods. Cryotherapy is the most common wart treatment method.

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However, a number of difficulties arise when applying this method. The first problem is that it has side effects. Second, it is painful, and all the warts must be treated together. Third, many treatment sessions are required. Accordingly, experts are looking for novel ways to treat this issue. Immunotherapy is a new treatment method which has lately been employed. Fortunately, it lacks the majority of the deficiencies cryotherapy has encountered. In the present study, we propose a fuzzy rule-based algorithm to detect which one of these two treatment methods has better results for each patient. Not only do we aim to find a good classifier, but we also recommend some useful and interpretable rules to physicians so as to assist them in treating their patients. This diagnosis would help these patients spend less time and money. To the best of our knowledge, our study is the first one conducted in the domain of wart treatment.

2. Datasets

The two datasets utilized in this study were collected in the dermatology clinic of Ghaem Hospital in Mashhad from January 2013 to February 2015. The datasets were collected from patients, with plantar and common warts, who had referred to the dermatology clinic. These two types of warts are two of the most common wart types.

The first dataset consists of seven features gathered when the cryotherapy method was applied. These features are demonstrated in Table 1. The second dataset has eight features collected when the immunotherapy method was employed. Table 2 presents these features. The class attribute in these datasets is the *Response to Treatment* feature.

T-test and chi-square test were used for statistical analysis, and the difference was considered significant when p-value < 0.05. Based on our results, there were no significant differences between age, time elapsed before treatment, surface area of warts, and the number of warts in these two datasets. Their p-values are 0.20, 0.37, 0.62, and 0.28, respectively.

These two types of treatment were selected since they are common wart treatment methods. These features, as important factors for treatment, were selected based on the physicians' opinion. They guessed that in employing these two methods for the treatment, these factors are probably more important than others. However, no research has been performed so far to confirm this hypothesis. A number of medical studies have been done to compare these two treatment methods [47–55]. However, none of them have been aimed at investigating this issue from the perspective of machine learning.

3. Method

The patients were randomly divided into two groups. Each group contained 90 patients. Once a patient came to clinic, he/she was sent to the first group. Then the next one was sent to the second group. This

Table 1
Features utilized in the cryotherapy method.

Feature name	Values	Mean ± SD ^a
Response to treatment	Yes or No	
Gender	47 Man 43 Woman	
Age (year)	15–67	28.6 ± 13.36
Time elapsed before treatment (month)	0–12	7.66 ± 3.4
The number of warts	1–12	5.51 ± 3.57
Types of wart (Count)	1- Common (54), 2- Plantar (9), 3- Both (27) ^b	
Surface area of the warts ^c (mm ²)	4–750	85.83 ± 131.73

^a Standard deviation.

^b Patients have both types of common and plantar warts.

^c Surface area of biggest wart.

Table 2
Features employed in the immunotherapy method.

Feature name	Values	Mean ± SD
Response to treatment	Yes or No	
Gender	41 Man 49 Woman	
Age (year)	15–56	31.04 ± 12.23
Time elapsed before treatment (month)	0–12	7.23 ± 3.10
The number of warts	1–19	6.14 ± 4.2
Types of wart (Count)	1- Common (47), 2- Plantar (22), 3- Both (21)	
Surface area of the warts ^a (mm ²)	6–900	95.7 ± 136.61
Induration diameter of initial test(mm)	5–70	14.33 ± 17.22

^a Surface area of biggest wart.

procedure continued until each group had 90 patients. The first group was treated by immunotherapy with candida antigen method. Treating these patients lasted up to three sessions by intralesional injection of vaccine. There was a three-week lapse between the sessions. The vaccination would halt in case a complete treatment was achieved before the third session. In the second group, the cryotherapy method with liquid nitrogen was applied. The treatment continued for a maximum of 10 sessions or until the complete treatment of warts occurred before the 10th session. In this method, there was a one-week time interval between the sessions. After three sessions of immunotherapy and ten sessions of cryotherapy, if the treatment was not achieved, we had to change the method because it was not effective [46].

3.1. Feature selection

One of the methods employed for feature selection is information gain. This method measures the reduction in the entropy of data. If a feature has the highest information gain, it can separate two classes completely. For the purpose of classification, this type of features is the best one. In other words, the higher the values of the information gain, the better candidate the feature is in the classification task [56]. In Eq. (1), H(T) indicates the entropy of the training data T.

$$H(T) = - \sum_{c \in \text{classes}} P(c) \log(P(c)) \tag{1}$$

where, c is the class value. The class value is “Response to treatment”. The probability that a record is in class c is denoted by P(c).

Eq. (2) indicates the information gain of the ath feature of the training data T.

$$IG(T, a) = H(T) - \sum_{v \in \text{values}(a)} \frac{| \{x \in T \mid x_a = v\} |}{|T|} \cdot H(\{x \in T \mid x_a = v\}) \tag{2}$$

where, x_a represents the value of the ath feature of example x.

3.2. Association rule learning

Association rule learning is used to discover the relationship between features in databases [57]. For each rule, support and confidence are defined. The support of a rule shows the proportion of data, which includes the antecedent and consequence of that rule. The confidence of a rule demonstrates the probability of finding the consequence of the rule in those item sets which include the rule antecedent [56].

Apriori is an algorithm for rule extraction. It is an algorithm for association rule learning over databases [58]. For rule extraction, at first, the high-probability conditions are extracted from the dataset. Next, these conditions are broken in all possible ways. Extracting the rules with the highest confidence is the final step [56]. In this research, only the rules having “Response to treatment” as their consequence were considered.

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