Reexamination of risk criteria in dengue patients using the self-organizing map

Tarig Faisal · Mohd Nasir Taib · Fatimah Ibrahim

Introduction

Dengue fever is widespread in many parts of the world, especially in the tropical and subtropical regions [5, 6, 8, 21, 30]. WHO classifies the dengue infection as dengue fever (DF) and dengue hemorrhagic fever (DHF)/dengue shock syndrome (DSS). Typically DF begins with a sudden temperature increase accompanied by headache, myalgia, macular rash, loss of appetite nausea, vomiting, abdominal pain, metallic taste of food, change in psychological state, and moderate thrombocytopenia [7].
Some DF patients might progress to DHF due to the increase in the vascular permeability. Typically, the DHF patients presence with some of the hemorrhagic evidence. According to the WHO, the first sign of DHF is fever or history of acute fever lasting between 2–7 days [30]. The second sign is the hemorrhagic tendencies evidenced by at least one of the following: positive tourniquet test (TT), petechiae, purpura, ecchymoses; bleeding from mucosa, gastrointestinal tract, injection sites or other location; haematemesis or melena. Third sign is thrombocytopenia (100,000 cells per mm^3 or less). Lastly, hemoconcentration (20% or more rise in the hematocrit (HCT) value relative to baseline average for the same age, sex, and population) or sings of plasma leakage such as pleural effusion, ascites, and hypoproteinaemia. Moreover, the WHO classified DHF patients into four categories. The DF patient who has fever and hemorrhagic manifestation (indicated by only positive tourniquet) is considered as DHF I. DHF II is the DF patient who has spontaneous bleeding plus the manifestations of DHF I. DHF III is the DF patient who has the signs of circulatory failure (rapid/weak pulse, narrow pulse pressure, hypotension, cold/clammy skin). Finally, DHF IV is considered as a DFIII patient who profound shock with undetectable blood pressure or pulse. Both DHF III and DHF IV are considered as DSS; this is a fatality stage.

Even though WHO criteria have been used for long time, recent studies have shown that several difficulties have been faced by the clinicians to apply these criteria [1, 31]. Shibani et al. reviewed the classification of dengue disease in the literature published between 1975 and 2005. The study found that the majority of the clinicians reported difficulties in applying all of the four criteria of the DHF cases [1]. The study suggested re-visiting the WHO criteria. Another study revealed that there is overlapping in the major clinical features that differentiate between the children with DF and DHF [31]. The study suggested that urgent research need to be conducted to understand the pathophysiologic mechanisms underlying the various clinical manifestations seen in dengue infections.

To overcome those difficulties, many studies [12, 13, 15, 19, 22, 24, 25] were conducted to determine the risk criteria or risk factor in dengue patients. All these studies used statistical analysis techniques to determine the risk criteria in the dengue patient. This study aimed to employ a new approach for reexamine the risk criteria in dengue patient based on unsupervised learning technique. One of the most powerful aids for visualizing, analyzing, and understanding the complexity of the high-dimensional data is self-organizing map (SOM) technique. It maps high-dimensional data into a simple low-dimensional display so that it can simplify the complexity of the data. Accordingly, clustering the SOM technique was employed in this study. Clustering the SOM technique involves two stages; at the first stage, the SOM is employed to cluster the dengue patients' data in order to visualize the common features of the data. In the second stage, the K-mean clustering algorithm is implemented to cluster the map's prototypes. To validate this technique, the obtained results were compared with the results obtained by implementing the K-mean clustering technique directly to the data. The advantages of clustering the SOM technique comparing with other conventional clustering techniques (K-mean clustering technique) are that extra compression and better separation for the clusters, visualizing the variables that makes the cluster different from others, illustrating the dimension of the data in each cluster, and demonstrating the relations among the variables in the clusters. The study was conducted by utilizing clinical data for a total of 195 hospitalized dengue patients.

Methods

Risk criteria for dengue patients

In order to overcome the limitation of the WHO criteria, many studies were conducted to determine the risk criteria or risk factor in dengue patients. Taweewong et al. claimed that the risk factors of DSS are bleeding, secondary dengue infection, and hemoconcentration of more than 22%. The study recommended that any DHF patient who has one of these criteria should be closely observed for early signs of shock [25]. M. Narayanan et al. declared that one of the criteria to hospitalize the suspected dengue cases is platelet count less than 50,000 cells per mm^3, since those patients will have high tendency to develop complications. The study suggested that more research need to be done to confirm this finding [22]. Conversely, Lucy et al. did not support the use of the of a platelet count value of less than 50 cells per mm^3 as an admission criteria in dengue infection since severe hemorrhage in DHF/DSS was not only caused by thrombocytopenia. Instead, the study recommended that the strongest risk factors for hemorrhage in DHF/DSS are extended duration of shock and a hematocrit within the normal-low range at the time of shock [19]. So, Shivbalan et al. used the combination of fever, hemoconcentration, platelet count less than 50,000 cells per mm^3 and elevated ALT to predict the spontaneous bleeding which reflect hemorrhagic tendency in dengue patients

[24]. Kalayanarooj et al. suggested that a positive TT, leukopenia, neutropenia, monocytopenia, and elevations of plasma AST levels can use to establish the clinical algorism for the high risk classification [15]. Based on statistical analysis and literature reviews, Ibrahim et al. classified the severity of the dengue disease to two groups: high risk patients and low risk patients. The classification was done based on the following criteria: Platelet (PLT) count less than or equal to 30,000 cells per mm^3, hematocrit (HCT) increase by more than or equal to 20%, and aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels rose by fivefold the normal upper limit for AST and ALT. The study declare that any patient has more than one criteria is consider in the high risk group other than this is considered as low risk group [12, 13].

Self-organizing map

The self-organizing map is an unsupervised learning technique. It consists of two layers of neurons. This type of neural network does not require any targets or outputs for learning. It receives a number of different multivariable input samples, discovers the significant relation among those samples, and presents them into two-dimensional map or display. The map consists of different clusters. Each cluster combines all the samples having the similar variable.

Similarly like any other neural network, the first step in constructing the self-organizing map is initializing the synaptic weights of the network. Once the network has been initialized, there are three steps involved in the construction of the self-organizing map Competition, cooperation, and synaptic adaptation stages [10].If the input sample vector and the weight vector can be represented by