A FUZZY INFERENCE SYSTEM FOR ASSESSMENT OF THE SEVERITY OF THE PEPTIC ULCERS

Kianaz Rezaei[1], Rahil Hosseini[1,2], and Mahdi Mazinani[1,2]

[1]Department of Computing, Kharazmi University, Tehran, Iran
[2]Faculty of Engineering, Islamic Azad University, Share-Qods Branch, Tehran, Iran

kianaz.rezae@gmail.com, rahilhosseini@gmail.com

ABSTRACT

Peptic ulcer disease is the most common ulcer of an area of the gastro- intestinal tract. The aim of this study is to utilize soft computing techniques to manage uncertainty and imprecision in measurements related to the size, shape of the abnormality. For this, we designed a fuzzy inference system (FIS) which emulates the process of human experts in detection and analysis of the peptic ulcer. The proposed approach models the vagueness and uncertainty associated to measurements of small objects in low resolution images In this study, for the first time, we applied soft computing technique based upon fuzzy inference system (FIS) for assessment of the severity of the peptic ulcer. Performance results reveal the FIS with maximum accuracy of 98.1%, which reveals superiority of the approach. The intelligent FIS system can help medical experts as a second reader for detection of the peptic ulcer in the decision making process and consequently, improves the treatment process.

KEYWORDS

Soft computing, Fuzzy inference system (FIS), Peptic ulcer.

1. INTRODUCTION

The second common cause of death from malignant disease is gastric cancer around the world. Detection and treatment of this painful disease has become one of the challenging medical problems.

Nowadays gastric ulcer is one of the most important concerns involves many factors especially widespread using of NSAIDs. Because of poorly understanding the pathophysiology of this disease [6], studies investigating new active compounds are needed. As well, various pharmaceutical products currently used for treatment of gastric ulcers are not completely efficient and cause many adverse side effects.

Peptic ulcer disease encompassing gastric and duodenal ulcer is the most prevalent gastrointestinal disorder [1]. They are caused by various factors such as drugs, stress or alcohol, due to an imbalance between offensive acid- pepsin secretion and defensive mucosal factors like mucin secretion and cell shedding [2]. Gastric ulcer therapy faces a major drawback due to the unpredictable side effects of the long-term use of commercially available drugs. It is shown that toxic oxygen radicals plays an important role in the etiopathogenesis of gastric damage

Dhinaharan Nagamalai et al. (Eds) : ACITY, WiMoN, CSIA, AIAA, DPPR, NECO, InWeS - 2014
pp. 263–271, 2014. © CS & IT-CSCP 2014 DOI : 10.5121/csit.2014.4527

[3].Currently, focus on plant research has increased all over the world and a large source of evidence has been collected to show immense potential of medicinal plants used in various traditional systems [4].

One of the main group of problems in medical science is related to diagnosing diseases based on different tests on patients. However, the final diagnosis of an expert is associated with difficulties. This matter led the physicians to apply computer aided detection and diagnosing tools in the recent decades.

A prime target for such computerized tools is in the domain of cancer diagnosis. Specifically, where breast cancer is concerned, the treating physician is interested in ascertaining whether the patient under examination exhibits the symptoms of a benign case, or whether her case is a malignant one [16].

The uncertainty issues in decisions making and medical diagnosis are related to incompleteness of medical science. computer aided detection (CAD) tools are presented with the purpose of facilitating the diagnosis of different diseases and acceleration of the treatment process [18]-[20]. One of the current applications of the CAD systems is to analysis the severity diagnosis of peptic ulcer presented in [10].

This study is concerned with the severity diagnosis of peptic ulcer and uses fuzzy inference systems for automatic diagnosis of disease. The required medical knowledge are aided by fuzzy systems and achieved data are from tested stomachs. This method assorts patients according to the length of ulcer.

The present study has been undertaken with the aim to assess the peptic ulcer severity using a fuzzy system.

2. LITERATURE REVIEW

In recent years, a major class of problems in medical science involves the diagnosis of disease, based upon various tests performed upon the patient. When several tests are involved, the ultimate diagnosis may be difficult to obtain, even for a medical expert. This has given rise, over the past few decades, to computerized diagnostic tools, intended to aid the physician in making sense out of the welter of data [16].

Soft Computing techniques based on the concept of the fuzzy logic or artificial neural networks for control problems has grown into a popular research area [11]-[13]. The reason is that classical control theory usually requires a mathematical model for designing controllers. The inaccuracy of mathematical modeling of plants usually degrades the performance of the controllers, especially for nonlinear and complex control problems. Fuzzy logic has the ability to express the ambiguity of human thinking and translate expert knowledge into computable numerical data.

A fuzzy system consists of a set of fuzzy IF-THEN rules that describe the input-output mapping relationship of the networks. Obviously, it is difficult for human experts to examine all the input-output data from a complex system to find proper rules for a fuzzy system. To cope with this difficulty, several approaches that are used to generate the fuzzy IF-THEN rules from numerical data have been proposed [11]-[13].

Today, medical endoscopy is a widely used procedure to inspect the inner cavities of the human body. The advent of endoscopic imaging techniques allow the acquisition of images or videos created the possibility for the development of the whole new branch of computer-aided decision support systems. This section summarizes related works specifically targeted at computer-aided decision support in the gastrointestinal tract [10].

A symbiotic evolution-based fuzzy-neural diagnostic system for common acute abdominal pain presents a symbiotic evolution-based fuzzy-neural diagnostic system (SE-FNAAPDS) for diagnosis of common acute abdominal pain (AAP) without professional medical examination [11]. The computer-assisted diagnostic system is formatted a multiple-choice symptom questionnaire, with a prompt/help menu to assist user in obtaining accurate symptom data using nothing more technologically sophisticated than a medical-type thermometer and stethoscope. Compared to traditional methods, diagnostic decisions from SE-FNAAPDS shows 94% agreement with professional human medical diagnosis and less CPU time for system construction. The presented method is useful as a core module for more advanced computer-assisted diagnostic systems, and for direct application in AAP diagnosis [11].

Non-ulcer dyspepsia (NUD) has been attributed to gastritis and Helicobacter infection in A Quantitative analysis of symptoms of Non-Ulcer Dyspepsia as related to age, pathology, and Helicobacter Infection. The Sydney classification enables dyspepsia symptoms assessed quantitatively in relation to Helicobacter infection and topographic pathology in different gastric compartments. The method presented in this study for 348 patients with the NUD. It studied the unconfounded effects of age, pathology, and Helicobacter. It was concluded that age was the most important determinant of dyspeptic symptoms, but not pathology or Helicobacter [7].
Computer-aided capsule endoscopy images evaluation based on color. Rotation and texture features were used as an educational tool to physicians.

Wireless capsule endoscopy (WCE) is a revolutionary, patient-friendly imaging technique that enables non-invasive visual inspection of the patient's digestive tract and, especially, small intestine. Experimental results demonstrated promising classification accuracy (91.1%) exhibiting high potential towards a complete computer-aided diagnosis system that will not only reduce the Wireless capsule endoscopy (WCE) data reviewing time, but also serve as an assisting tool for the training of inexperienced physicians [9].

3. MATERIALS AND METHODS

Fuzzy set A in universe of discourse X can be defined as a set of ordered pairs of element x in X and the grade of membership of x, μ_A (x), to fuzzy set A [15] as follows:

$$A = \{(x, \mu_A(x)) | x \in X\}$$

where the two dimensional membership function μ_A (x) is a crisp value between 0 and 1 for all $x \in X$. Linguistic terms are modelled using fuzzy sets. One of the parameters in the design of a fuzzy logic is the number of fuzzy sets associated to a linguistic term. Fuzzy inference system as a soft computing method mimics cognitive reasoning of the human mind based on linguistic terms for performing tasks in a natural environments.

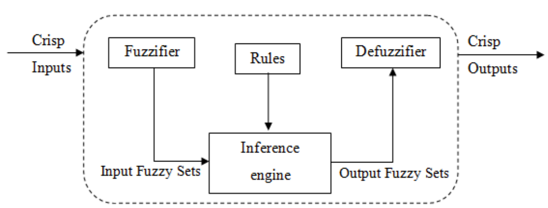

Figure 1. Architecture of a Fuzzy Inference System

The fuzzy inference system is a rule-based system that uses fuzzy logic, rather than Boolean logic, to reason about data. Its basic structure includes four main components, as depicted in Figure 1: (1) a fuzzifier, which translates crisp (real-valued) inputs into fuzzy values; (2) an inference engine that applies a fuzzy reasoning mechanism to obtain a fuzzy output; (3) a defuzzifier, which translates this latter output into a crisp value; and (4) a knowledge base, which contains both an ensemble of fuzzy rules, known as the rule base, and an ensemble of membership functions, known as the database[16].

The fuzzy inference system is a popular computing framework based on the concepts of fuzzy set theory, fuzzy if-then rules, and fuzzy reasoning. It has found successful applications in a wide variety of field, such as automatic control, data classification, decision analysis, expert systems, and pattern recognition.

This Mapping is accomplished by a number of fuzzy if-then rules, each of which describes the local behavior of the mapping. In particular, the antecedent of a rule defines a fuzzy region in the input space, while the consequent specifies the output in the fuzzy region.

Fuzzy logic models can be developed from expert knowledge or from process (patient) input-output data. In the first case, fuzzy models can be extracted from the expert knowledge of the process. The expert knowledge can be expressed in terms of linguistics, which is sometimes faulty and requires the model to be tuned. This process requires defining the model input variables and the determination of the fuzzy model system parameters.

Sugeno, or Takagi-Sugeno-Kang, method of fuzzy inference. Introduced in 1985, it is similar to the Mamdani method in many respects. The first two parts of the fuzzy inference process, fuzzifying the inputs and applying the fuzzy operator, are exactly the same. The main difference between Mamdani and Sugeno is that the Sugeno output membership functions are either linear or constant [21]. This study applies the Sugeno fuzzy inference model in order to present a measure of the sevirity of the peptic ulcer in the output of the FIS.

4. PEPTIC ULCER SPECIFICATION

This section explains the chemical process and animals used in laboratory experiments. The features extracted in the experiments were considered as the input of the FIS. These features are explained in details in this section.

The present study was tested on male Wistar rats for 15 days protected the gastric mucosa against the damage induced by indomethacin (25, 50 and 100 mg/kg) [17]. Male Wistar rats weighing 175 - 220 g were used in the study. The animals were in 6 separate groups consisting of 5 rats. The quantitative evaluation of experimentally induced gastric lesions is a problematic and error-prone task due to their predominantly multiple and irregularly shaped occurrence. The simplest type of lesion index for quantification of chemically induced ulcers were described as the cumulative length (mm) of all hemorrhagic erosions. The width of lesion has also been taken into account (ulcer index = length -width) [17]. Figure 2 shows Microscope views of a sample stomach of a rat with ulcer.

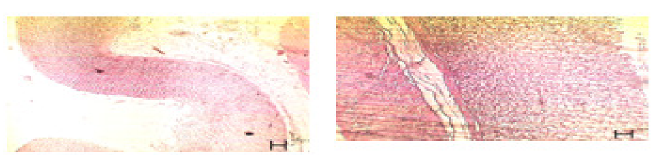

Figure 2. Microscope views of the rats stomach with ulcer

5. FUZZY MODELING OF THE FEATURE CHARACTERIZATION OF PEPTIC ULCER

In order to apply soft computing techniques based on the FIS for severity assessment of the peptic ulcer, we applied two methods as follows:

1) FCM (Fuzzy C-Means Clustering): for scatter partitioning of the input space and automatic generation of the membership functions
2) ANFIS (Adaptive Neuro-Fuzzy inference system) for learning the FIS rules and tuning of the membership functions

The rest of this section explains the abovementioned processes in details.

5.1. Scatter partitioning of the input space

Fuzzy c-means (FCM) is a data clustering technique wherein each data point belongs to a cluster to some degree that is specified by a membership grade. This technique was originally introduced by Jim Bezdek in 1981 as an improvement on earlier clustering methods. It provides a method that shows how to group data points that populate some multidimensional space into a specific number of different clusters.

In this study we used Fuzzy Logic Toolbox in Matlab to implement the FIS. The FCM starts with an initial guess for the cluster centers, which are intended to mark the mean location of each cluster. The initial guess for these cluster centers is most likely incorrect. Additionally, fcm assigns every data point a membership grade for each cluster. By iteratively updating the cluster centers and the membership grades for each data point, FCM iteratively moves the cluster centers to the right location within a data set. This iteration is based on minimizing an objective function that represents the distance from any given data point to a cluster center weighted by that data point's membership grade Input features for assessment of the peptic ulcer are as Follows:

For each input and output variable of the FIS, three linguistic terms (Low, Medium and High) were considered. Table 1 shows all input variables of the peptic ulcer FIS.

Table 1. The FIS input variables

No.	Feature	Description
1	Score 1	Each fifth petechia was calculated as 1 mm
2	Score 2	lesion length between 1 and 2 mm
3	Score 3	lesion length between 2 and 4 mm
4	Score 4	lesion length between 4 and 6 mm
5	Score 5	lesion length more than 6 mm
6	Indomethacin	Explained in Section IV
7	Cimitidine	Explained in Section IV

The FIS output variable were considered ulcer index (UI) which represents severity of the peptic ulcer. The ulcer index (UI) was calculated using the following formula:

$$UI = (1*S1)+(2*S2)+(3*S3)+(4*S4)+(5*S5) \quad (1)$$

where S_1, S_2, S_3, S_4, S_5 are related to the score 1 to score 5, respectively.

5.2. ANFIS (Adaptive Neuro-Fuzzy Inference System)

This syntax is the major training routine for Sugeno -type fuzzy inference systems. anfis uses a hybrid learning algorithm to identify parameters of Sugeno-type fuzzy inference systems. It applies a combination of the least-squares method and the backpropagation gradient descent method for training FIS membership function parameters to emulate a given training data set. ANFIS can also be invoked using an optional argument for model validation. We applied the ANFIS for learning rules in the FIS and tuning of the membership function parameters.

The flowchart of the approach applied for learning and tuning of the FIS parameters using the ANFIS approach is shown in Figure 3.

6. EXPERIMENTS RESULTS

In the process of the FIS parameter specification using the ANFIS model, we have a dataset including 30 real patients diagnosed with peptic ulcer information. We partitioned the dataset into two parts:

1) Training (70%)
2) Testing (30%)

Figures 4 to 9 represent the performance results on training and testing datasets in terms of the root mean square error (RMSE) and the histogram of the errors. The performance results are summarized in Table 2.

Table 2. System Performance on Train and Test datasets

	Accuracy
Average(train)	99.65%
Average(test)	97.74%

The rules and membership functions of the FIS for peptic ulcer risk assessment was designed using fuzzy c-means (FCM) clustering by extracting a set of rules that models the data behaviour using Fuzzy Logic Toolbox and ANFIS Toolbox in Matlab are shown in Figures 9 to 14. The rule extraction method first uses the FCM method to determine the number of rules and membership functions for the antecedents and consequents. Then ANFIS is applied to tune the FIS parameters. Table 3 shows the resulted FIS before training and after training process using the ANFIS approach. The RMSE was used as performance measure during evaluation process. The result of the RMSE and the histogram of the errors on train and test datasets are shown in Figures 3 to 8.

Table 3. Comparison of Results

Methods	**Accuracy**
FCM	94.9%
ANFIS	98.1%

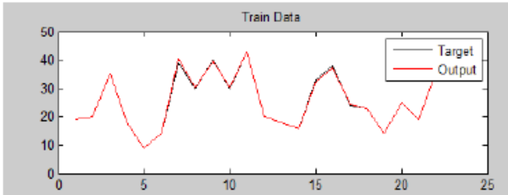

Figure 3. This section shows the Train data. Almost coincides target and Output.

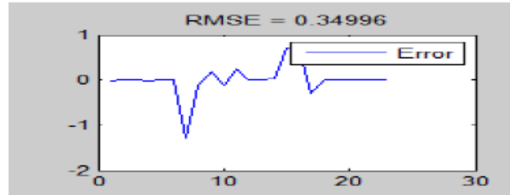

Figure 4. RMSE: Shows the maximum and minimum errors in the Train Data.

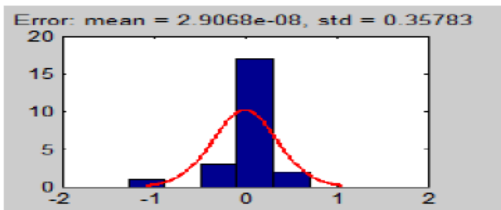

Figure 5. The third part is the histogram of the errors,and shows the mean and standard deviation of the error.

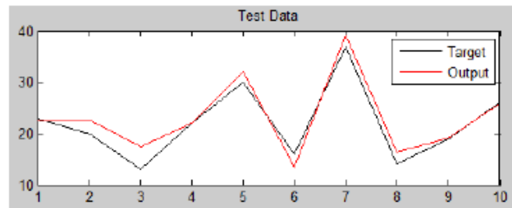

Figure 6. This section shows the Test data. There is between Output and Target.

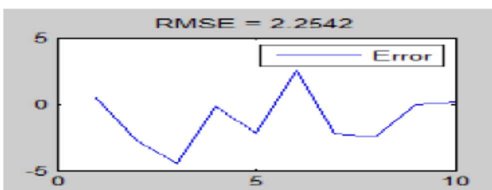

Figure 7. RMSE: Shows the maximum and minimum errors in the Test Data.

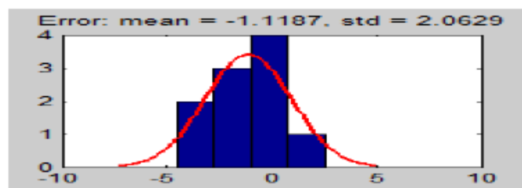

Figure 8. The third part is the histogram of the errors, and shows the mean and standard deviation of the error.

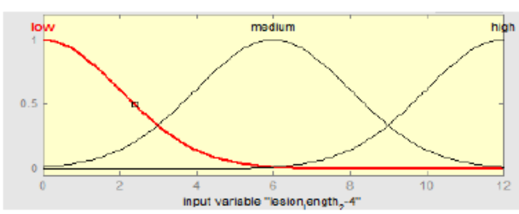

Figure 9. Membership functions related to the Score 3: lesion length between 2 and 4 mm

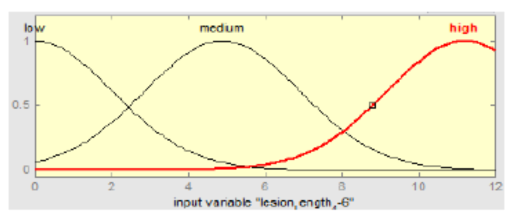

Figure 10. Membership functions related to the Score 4: lesion length between 4 and 6 mm

7. Conclusion

In this study, for the first time, a soft computing technique based upon fuzzy inference system (FIS) was proposed for the problem of peptic ulcer assessment. The FIS was generated using FCM and tuned using the ANFIS model. Performance results on a dataset including real patients reveal the FIS with maximum accuracy of 98.1%, which reveals superiority of the approach. The intelligent FIS system can help medical experts as a second reader for detection of the peptic ulcer in the decision making process and consequently, improves the treatment process.

REFERENCES

[1] Umashanker, M. and S. Shruti, Traditional Indian herbal medicine used as antipyretic, antiulcer, anti-diabetic and anticancer: A review. IJRPC, 2011. 1: 1152-1159.

[2] M. Shakeerabanu, K. Sujatha, C. Praveen-Rajneesh and A. Manimaran, "The Defensive Effect of Quercetin on In- domethacin Induced Gastric Damage in Rats," Advances in Biological Research, Vol. 5, No. 1, 2011, pp. 64-70.

[3] Cadirci, E., et al., Effects of< i> Onosma armeniacum</i> root extract on ethanol-induced oxidative stress in stomach tissue of rats. Chem Biol Int, 2007. 170(1): p. 40-48

[4] Anosike, C.A., et al., Anti-inflammatory and anti-ulcerogenic activity of the ethanol extract of ginger (Zingiber officinale). Af J Biochem Res, 2009. 3: 379-384.

[5] M. Khanavi, R. Ahmadi, A. Rajabi, S. Jabbari-Arfaee, G. Hassanzadeh, R. Khademi, A. Hadjiakhoondi and M. Sha- rifzadeh, "Pharmacological and Histological Effects of Centaurea bruguierana ssp. belangerana on Indometha- cin-Induced Peptic Ulcer in Rats," Journal of Natural Medicines, Vol. 66, No. 2, 2012, pp. 343-349.

[6] P. Malfertheiner, F. K. Chan and K. E. McColl, "Peptic Ulcer Disease," Lancet, Vol. 374, No. 9699, 2009, pp. 1449-1461.

[7] S. T.Lai , K.P.Fung, F.H. Ng. and K. C . Lee"A Quantitative Analvsis of Svmptoms of Non-Ulcer Dvspepsia as Related to Age pathology, and Helicobacter Infection" 1996,vol. 31,No.11,pages 1078-1082.

[8] G.Gopu, R.Neelaveni, K.Porkumaran "Noninvasive Technique for Acquiring and Analysis of Electrogastrogram" IJCA Special Issue on "Computer Aided Soft Computing Techniques for Imaging and Biomedical Applications" CASCT, 2010.

[9] Vasileios S. Charisis, Christina Katsimerou, Leontios J. Hadjileontiadis, Christos N. Liatsos, George D. Sergiadis "Computer-aided Capsule Endoscopy Images Evaluation based on Color".

[10] M. Liedlgrubera,_, A. Uhla "A Summary of Research Targeted at Computer-Aided Decision Support in Endoscopy of the Gastrointestinal Tract" Technical Report 2011-01.

[11] G. G. Towell and J. W. Shavlik, ―Extracting refined rules from knowledge-based neural networks,‖ Machine Learning, vol.13, pp.71-101, 1993.

[12] C. J. Lin and C. T. Lin, ―An ART-based fuzzy adaptive learning control network,‖ IEEE Transactions on Fuzzy Systems, vol.5, no.4, pp.477-496, 1997.

[13] C. F. Juang and C. T. Lin, ―An on-line self-constructing neural fuzzy inference network and its applications,‖ IEEE Transactions on Fuzzy Systems, vol.6, no.1, pp.12-31, 1998.

[14] Jyh-Shing Roger Jong, Chapter 4, Fuzzy Inference System (Jang, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence.)

[15] Zadeh, Fuzzy Logic, Neural Networks, and Soft Computing-1994

[16] Carlos Andre´s Pen˜a-Reyes, Moshe Sipper, A fuzzy-genetic approach to breast cancer diagnosis, Artificial Intelligence in Medicine 17 (1999) 131–155.

[17] Ghazaleh Moghaddam1, Mohammad Sharifzadeh2, Gholamreza Hassanzadeh3, Mahnaz Khanavi4,5, MannanHajimahmoodi; Anti-Ulcerogenic Activity of the Pomegranate Peel (Punicagranatum) ,Published Online October 2013.

[18] M. Mazinani, J. Dehmeshki, R. Hosseini, S.D. Qanadli, "Afuzzy automatic method for measuring the volume of the stenosis by modeling thepartial volume problem in the coronary artery", USGG 2009, Lausanne, Switzerland(2009).

[19] RahilHosseini, J. Dehmeshki, S. A. Barman, MMazinani, S.D. Qanadli, "A Fuzzy Logic System for Classification ofthe Lung Nodule in Digital Images in Computer Aided Detection", In Proc.of Int. Conf. of Digital Society (ICDS), IEEE, September (2010), pp. 255- 259.

[20] RahilHosseini, S. D. Qanadli, S. Barman, M. Mazinani, T.Ellis, and J. Dehmeshki, "An Automatic Approach for Learning and Tuning Gaussian Interval Type-2 Fuzzy Membership Functions Applied to Lung CAD Classification System", IEEE Transactions on Fuzzy Systems, vol. 20, No. 2, April (2012), pp. 224-234.

[21] Sugeno, M., Industrial applications of fuzzy control, Elsevier Science Pub. Co., 1985.

AUTHORS

Kianaz Rezaei (born February, 1990), obtained her B.Sc. degree in Computers-Soft computing from Islamic Azad University, Share-e-Qods Branch, Tehran, Iran during 2012, and currently pursuing Masters Degree from Kharazmi University, Tehran, Iran.

Rahil Hosseini is assistant professor in software engineering and soft computing at Azad University. She is a member of the Digital Imaging Research Centre (DIRC) in the Faculty of Science, Engineering and Computing at Kingston University, London. She received her BSc at Teacher training University in Tehran followed by her MSc in software engineering. She commenced her PhD at Kingston University London. Her main area of interest in research is in the fields of soft computing, fuzzy modelling and pattern recognition in data mining problems and medical image analysis, specifically cancer diagnosis. She has professional work experience in the field of data mining, medical image analysis and fuzzy modelling for uncertain environments. She has published journal and conference papers in data mining, soft computing, distributed systems, fuzzy modelling, and pattern recognition for medical image analysis and cancer diagnosis.

Mahdi Mazinani is assistant professor in electronic engineering and image processing at Azad University. He is a member of the Quantitative Medical Imaging International Institutes (QMI3) and Digital Imaging Research Centre in the Faculty of Science, Engineering and Computing at Kingston University, London. After completing his BSc degree in Electronic engineering at Semnan University (securing the first rank) he completed his MSc degree in the Semnan University with first rank. He commenced his PhD. His main area of interest in research is in the field of medical image analysis. His work is focused on research into novel image analysis techniques to enable the recognition and quantification using CTA images.

He has published papers in the detection and quantification of the coronary arteries using fuzzy and medical image analysis techniques.