INFO CARDIO ADVANCED MEDICAL IMAGE ANALYSIS AND AUTOMATION OF ANGIOPLASTY USING GIIM, IISM WITH CBR & RBR INTELLIGENCE

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ABSTRACT

InfoCardio, A system consisting of two image processing modules and two intelligent modules, the Intelligent Image Segmentation Module IISM, Global Image Interpretation Module GIIM, Case Based Reasoning CBR and Rule Based Reasoning RBR. Info Cardio uses a combination of an image processing technique and a knowledge based intelligent scheme that interactively cooperate together to get segments and labels for different sections of the image and process. GIIM is implemented using intelligent methods of CBR and RBR for manipulating specific knowledge related to the image interpretation problem. CBR/RBR can be implemented in both IISM and GIIM. **Info Cardio** supports visualization and eradication of Cardiological diseases and helps early and precise diagnosis for further treatment. Info cardio is designed for automation of angioplasty. It can also be designed for various other surgical procedures. The main advantage present here is it consults the doctor for any further action on the patient. So its safe and secure. The main stress is on Perfection and Life rather on automation and time.

Keywords : Advanced Medical Image Analysis, Snake methodology, Vessel change detection, Global Image Interpretation, Intelligent Image Segmentation, Case Based Reasoning, Angioplasty.

1. INTRODUCTION

In many clinical scenarios, images from several modalities may be acquired and the diagnostic task is to mentally combine or fuse this information to draw useful clinical diagnosis. In cardiology, physicians work on different image modalities, none of which contains the complete information about the vascular disease[1] – sound, ultrasound and angiography. The first objective is to develop a new tool to support conceptualization and mental combination of all this data coming from different instruments. This may be eliminated by application of INFO-CARDIO. INFO CARDIO can be used for automation of Percutaneous Transluminal Coronary Angioplasty (PTCA), a surgical procedure which is followed for removing the blocks in the coronary arteries. However the scope of INFO CARDIO is not restricted to PTCA alone, it can be used even for Renal Angioplasty, Retinal Angioplasty etc … Info Cardio is a boon to people who are allergic to foreign bodies as it eliminates Stents, and hence it is an increase in safety for the patient.

A. GIIM

Generally image interpretation is viewed as a planning task. There are a large number of medical image interpretation systems in the past. Conventional image interpreting architectures have also been employed in interpreting abdominal CT images. Unfortunately, these architectures are characterized by performance brittleness and a lack of learning capability. A sufficient degree of system robustness as well as an ability to continuously learn from problem solving experiences is important for open-textured, weak-theory domains. Beyond the conventional approaches, some systems focus on architectural aspects, others on knowledge modeling methods. Info Cardio is based on knowledge Based interpretation technique.

B. IISM

The aim of image segmentation module is to partition an image into a number of non-overlapping regions that form a complete tessellation of the image plane. A wide range of work has been undertaken to achieve this aim and segmentation has found diverse applications ranging from medical to military uses. It is still a subject of on-going investigation and it cannot be conclusively stated that the segmentation problem has been solved.

C. Case Based Reasoning (CBR) and Rule based Reasoning (RBR)

It is a problem-solving paradigm which utilizes specific knowledge of previously experienced, concrete problem situations (cases) stored in a "Case Base (CB)”. A new problem is solved by finding a similar past case, and reusing it for the new problem situation. **CBR supports sustained learning since a new experience is retained each time a problem has been solved**. These problems are selected from the case base according to the rules adopted given by RBR.

2. MOTIVATION

The *algorithmic* way of processing and analyzing digital images has developed powerful means to interpret specified kinds of images, but failed in providing general image understanding methods that work on all kinds of images. This is mostly due to the fact that every picture can be interpreted in many ways. Thus, we need to build models about the expected contents of images in order to enable the user to “understand" them more precisely. Another important goal of *knowledge-based* image analysis (KBIA) is to make the knowledge of how to apply, compose and program image processing algorithms explicit, and thereby help the non-expert on the field of KBIA to do efficient image processing/analysis.

The performance of an image processing system depends heavily on the design of knowledge model structure. The model has to address and solve the following issues :

- Adapting to variations among the knowledge model and instances
- Planning of processing operations.
- Controlling the processing flow during the analysis.
- Representing and using knowledge into image processing
- Implementing evaluation mechanisms for image processing quality
- Recognizing objects by matching them with models and resolving conflicts between contradictory hypotheses.

3. OBJECTIVE

1. Info Cardio is designed using the 3 modules GIIM, IISM, CBR.
2. The Medical image is scanned first and then it is processed using image processing techniques like…..Filtering, Segmentation, Lower image interpretation., Object recognition
3. A CBR system is implemented for comparing with previous experience with segmented images. The function of the CBR module it to assign suitable low level labels for the segments generated by the image processing module and Knowledge base system for storing any useful knowledge to direct the operation of the image processing and the CBR systems.
4. A central interface that acts like a coordinator among the different modules. It also serves as a communicator with the GIIM.
5. Again this result is redirected to CBR to carry out the necessary solutions after assessment and produce the needed guidance to the concerned.

4. ALGORITHMS USED

A. Active contour model (SNAKE Methodology)

A "snake" [14] is an elastic curve that evolves from its initial shape and position as a result of the combined action of external and internal forces [14] The external forces push the snake towards features of the image, whereas internal forces model the elasticity of the curve. In parametric terms the snake is a curve $u(s) = (x(s), y(s))$ where $s \in [s_0,..,s_{n-1}]$ and $s_0 = s_{n-1}$ for closed curves. The internal energy is defined as:

$$E_{\text{int}}(u) = \int \alpha |u_s|^2 \, ds + \int \beta |u_{ss}|^2 \, ds$$

The first term is called "membrane energy" and defines the resistance of the deformable model to stretching. The second term is called "stiffness energy" and defines the resistance of the model to bending. The external energy is generally defined from a potential field P:

$$E_{ext}(u) = \int P(u(s))ds$$

A typical potential field for a snake attracted to image edge points is given by:

$$\text{P(u(s))} \propto -|\text{G}_\sigma * \nabla I(u(s))|$$

Where $u(I)$ is the intensity value of the image pixels and G_σ is a Gaussian smoothing function of scale σ. In general, the potential must define a surface which minima correspond as closely as possible to the image features of interest. The total energy of the snake is the sum of the external and internal energies:

$$E_{snake}(u) = E_{\text{int}}(u(s)) + E_{ext}(u(s))$$

The solution to the problem of detecting a contour is obtained by minimization of the energy function, which is generally performed using variational principles and finite difference techniques. The snake with the smaller energy corresponds to the desired object contour. The snakes make extensive use both of image pixel intensity and ultrasound data to visualize stenosis in 2D and 3D images, thus helping doctors conceptualize the degree and severity of the disease. (For eg. We take angiography).The novel knowledge-processing features of the application are the following - the automatic segmentation method for the catheter in the angiographic images; three-dimensional visualization of the vessel layers; real 3D distance measurements between two given points in the vessel; exact correspondence between IVUS and angiographies. The system has achieved a high level of perceptual and conceptual sofistication via the extensive use of the "snake" methodology.

B. Vessel Change Detection Algorithm (Modification of Can's Algorithm)

In order to build an automated system with which to detect changes in vessel widths, three requirements must be met.

First, there must be a method of finding the vessels in an image.

Second, there needs to be a method of identifying corresponding vessel pieces.

Third, there must be a way to measure and identify the changes in width.

Measuring Change in Vessel Diameter

To avoid these types of errors, a new methodology is proposed to measure widths directly as the distance between two points. These two points will be defined as points located on smooth curves representing the detected boundaries that are perpendicular to the vessel orientation and are located. By considering width measurements along corresponding points on corresponding vessels, widths can be compared to identify differences. [13]

If these differences exceed the ”normal” maximum expected difference to account for vessel change caused by the cardiac cycle of 4.8%, these vessel portions would be flagged as sites where differences have been observed.

Can’s original algorithm uses a single global threshold to determine vessel boundaries. This single global threshold resulted in missed vessels, particularly in images with a large degree of variation caused by uneven illumination or the presence of pathologies. By breaking the image into smaller regions and calculating thresholds for each region, more appropriate thresholds were calculated and better results achieved.

Fig: The left and middle images demonstrate possible results of the original algorithm in two different images. It would be difficult to compare the three recognizable vessel segments as each set of results contains only two segments that differ greatly. The image on the right depicts how the current algorithm, would always represent the results as three separate segments in all images and as such would be much easier to compare.

5. LOGICAL / IMPLEMENTATION DIAGRAMS

Fig 1: Vessel change detection algorithm

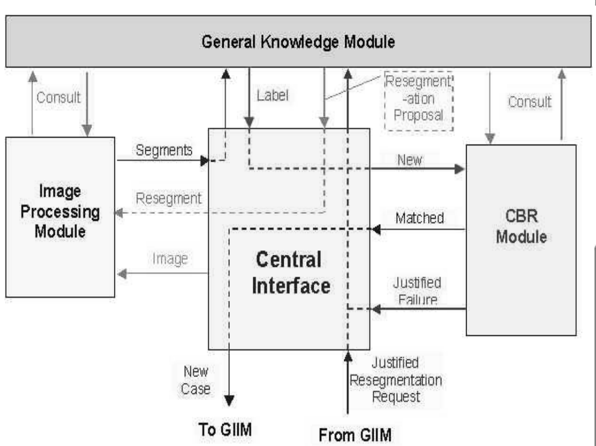


Fig 2: The IISM Module

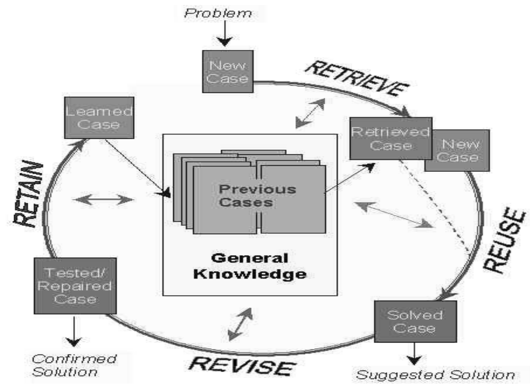


Fig 3: CBR cycle

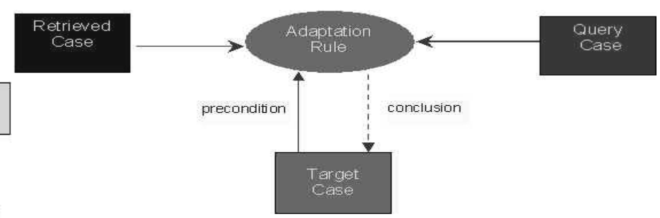
A general CBR cycle may be described by the following four processes namely

1. **RETRIEVE** the most similar cases and rank them according to their similarity.
2. **REUSE** the Knowledge in one case to solve the new problem.
3. **REVISE** the proposed solution.
4. **RETAIN** the parts of this new experience likely to be useful for future problem solving.

Rule Based Reasoning (Data from Case Base)

i) Completion Rules : describe how to infer additional features (attributes) out of known features of an old case (object).

ii) Adaptation rules: describe how an old case can be adapted to fit the current query (problem).



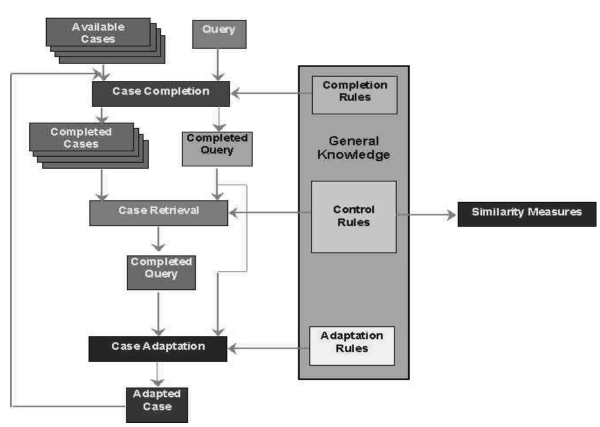


Fig 4: Incorporating GK rules using CBR

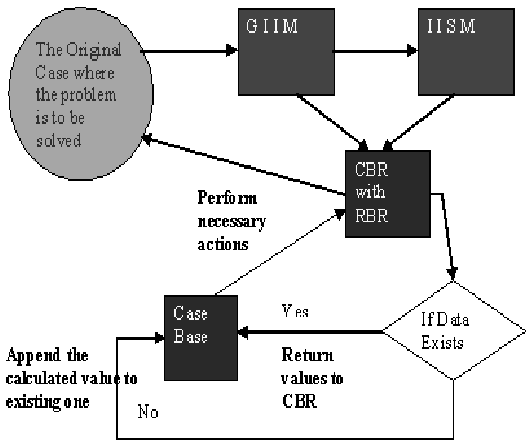


Fig 5 : The Implementation of the system

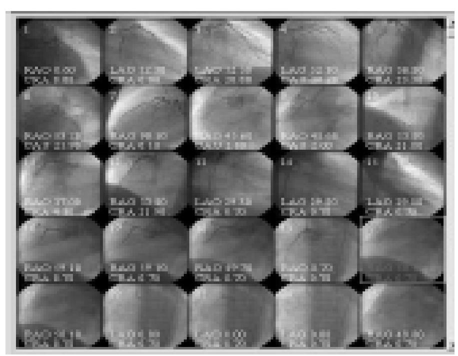


Fig 6: Image Labels 5x5 Matrix constructed for reconstruction of path of the catheter [14]

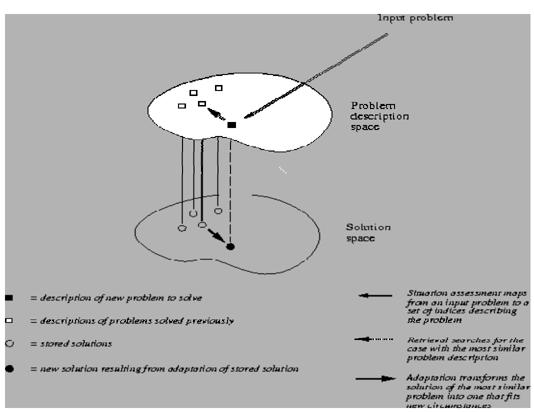


Fig 7: Intelligence of our CBR System which takes decision based on existing cases and new case [13]

6. IMPLEMENTATION OF THE SYSTEM Percutaneous Transluminal Coronary Angioplasty or PTCA

In the on-line processing mode the information about the medical case and the patient history is entered and a set of image labels (fig 6) are provided using GIIM and IISM methodology to CBR for reconstructing the path of the catheter. This is done by using two pairs of angiographic series one at the beginning of the pullback and another at the end. An acquisition protocol (Algorithms Proposed Above) is proposed to assure the minimal possible error in the reconstruction of the path covered by the intravascular ultrasound (IVUS) catheter during its pullback along the vessel. The second catheter which is placed at the inside end gives the info about the block and instructs the appropriate needle to apply appropriate pressure. Meanwhile the info of the block is sent to the CBR system and it checks with the existing database and computes the new action and will inform the procedure to the doctor present. If the doctor does not prefer this method, it computes various other methods and informs, out of which he / she can choose one.

To perform this acquisition protocol, the application is equipped with a real-time video and electro-cardiographic (ECG) module consisting in an Euresys video-capture card and a SoundMax soundcard. A video output of the angiographic equipment, containing the same information shown in the laboratory monitors, is used as input to the system. A region of interest (ROI) of 512x512 [14] pixels containing the angiography is defined on the input signal to accelerate the storage process. For the ECG signal acquisition, the sound card with a voltage and current attenuator is used to avoid over-saturation. The sound card works as a band-pass filter. The input signal has to be integrated in a sliding window in order to recover its original shape. Once the ECG is recovered and the angiographic images recorded, the angiographies corresponding to the end of the S curve of the ECG are automatically selected to assure maximum ventricular volume. The same recording procedure is taken for the IVUS data. The application incorporates a Case Base for offline analysis of angiographic and IVUS data. This Case Base presents a list of all the medical cases recorded [13] before and it selects the needed/most appropriate one. The CBR displays the data about the case, with the capability of running in a simulation mode. In the case of IVUS data the images can be easily loaded into Case Base, by only providing to the system information about the used frame rate and the distance (in millimeters) between two consecutive grid marks in the IVUS image. a new module of the application helps define closed models of the vessel layers. Then at last the CBR module calculates the intensity of the block and proposes the appropriate pressure to fragment the block.

A. Hard ware setup used

1. ECG equipment,
2. Euresys Video capture card
3. Sound max Sound Card
4. The Catheters with the camera.

B. Test Results

The Part of software was performed in simulation mode and was successful. This implementation was on Image processing. It was implemented as a part of fulfillment of the degree. Objectives 1 and 2 are satisfied with this implementation. Testing was done on recorded images retrieved from actual Angioplasty done on the relative of the author.

7. FEATURES

3D vessel reconstruction is possible, interface and model interactivity and ability for tissue characterization. The 3D visualization is performed in "near" real-time and the existing medical imaging instruments perform geometric 3D visualization, whereas using the "snake" methodology the 3D model is more realistic.

This is performed in a complex way from the fusion of IVUS with angiographies along with CBR and IISM .It is very handy for the cardiologist where the catheter path is corrected by itself, thus minimizing computation and error cost.

8. CONCLUSION

This is a unique venture which combines two Image Processing Modules, and two Artificial Intelligence Modules, each a special innovation in its own field. The Modification of Can's Algorithm is done to be implemented in the Coronary arteries. The generalization of the algorithm is done here. Moreover, Snake methodology is generally used as a part of segmentation Module. Here a new methodology is proposed, wherein the same algorithm is also used for calculating the width of the artery and help in tracing the path without hitting the edges-the main implementation feature of this proposal.

Info Cardio is an advanced and sophisticated tool for cardiovascular practice. This system renders efficient analysis of the images. Although Info Cardio is based on Angioplasty, It can be implemented in many similar applications. By the use of CBR Info Cardio has made the work of cardiologist easier. That is the CBR calculates the appropriate pressure to be applied on the block. Development of a more flexible and more semantically oriented interface is my aim in the future and the hardware implementation of this project will be done at the earliest.

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