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Kidney stone classification using Deep Neural Networks and facilitating diagnosis using IoT

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Abstract-*Kidney stone is a hard piece of solid formed due to minerals in urine. These stones are formed by combination of genetic and environmental factors. It is also caused due to overweight, certain foods, some medication and not drinking enough of water. There are 5 different types of kidney stones. Every kidney stone crystal has its own distinctive illness and entails specific treatment. There have been many research projects to determine the existence of kidney stones. To immediately classify the type of kidney stones is what we have proposed to do. A MATlab model which efficiently classifies the kidney stone images using weight estimating classifier is to be determined. The kidney stone images are acquired and preprocessed initially. The image is converted into a Gray Image and only the area of study is cropped out. The textures features are segmented by Active Contour Segmentation method and the features are classified using the Deep Neural Networks model. Then, using IoT the data is sent to the Cloud from which it can be accessed by doctors and patients, alike.*

Keywords: Image Processing, Kidney stone classification, Deep Neural Networks, IOT

1.INTRODUCTION

1.1 Introduction to image processing:

Image Processing is a technique to improve raw images received from cameras/sensors for various applications.Image processing is used to convert an image signal into a physical image. The actual output can be physical image or the characteristics of an image.

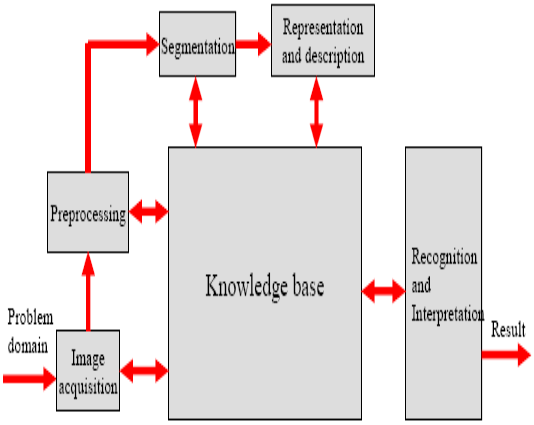
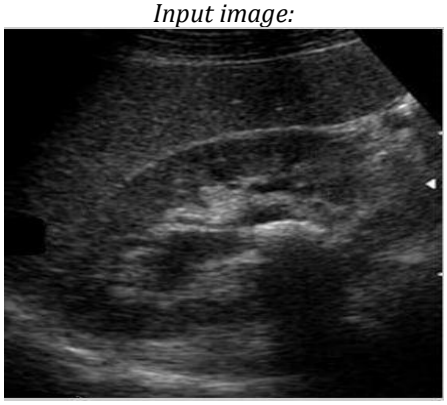


Fig: Fundamental steps in digital image processing

[1]The kidney image captured through the ultrasound device is taken as input and the method applies the filter to remove the noise present in the image. The filter is applied at different orientation which removes the external noise present in the image. The noise-removed image is enhanced by Digital Image Processing techniques.

Input image:



1.2 RGB color model:

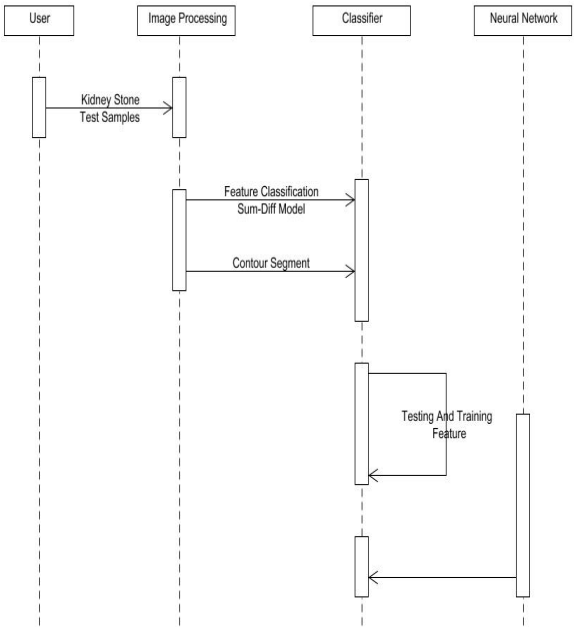
A depiction of additive color mixing. Estimate of primary color lights on a screen shows secondary colors where two overlap; the combination of all three of red, green, and blue in appropriate intensities makes white.

Fig: RGB color model

In the RGB color model red, green, and blue light is fused together in several ways to reproduce a broad collection of colors. The model's name comes from the initials of the three primary colors, red, green, and blue. The main aim of the RGB color model is for display of

images in electronic systems, such as televisions and computers.

Sequence diagram:



2.CONVERTING COLOR TO GRAYSCALE

To convert any color to a grayscale representation of its luminance, first one must obtain the values of its red, green, and blue (RGB) primaries in linear intensity encoding. To convert a gray intensity value to RGB, all the three primary color components red, green and blue is set to the gray value.[2]

Grayscale image:

3.IMAGE ENHANCEMENT

Some images obtained from digital cameras lack in contrast and brightness because of the restrictions of illumination environments while capturing image. Images may have various types of noise. In image enhancement, the goal is to emphasize certain image features for subsequent study or for image display. Image enhancement is suitable for feature extraction, image analysis and an image display. The enhancement process simply emphasizes certain specified image characteristics.

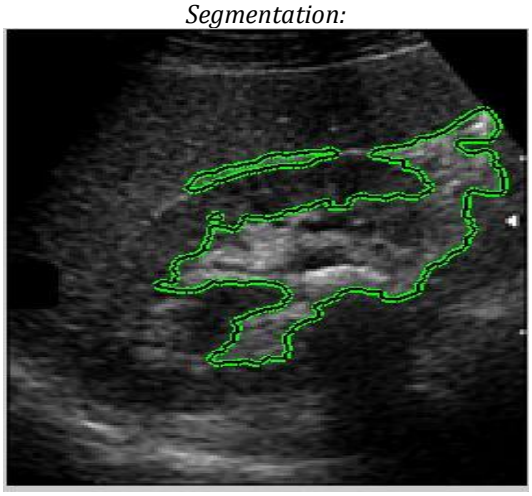
Enhanced image:

4.IMAGE SEGMENTATION:

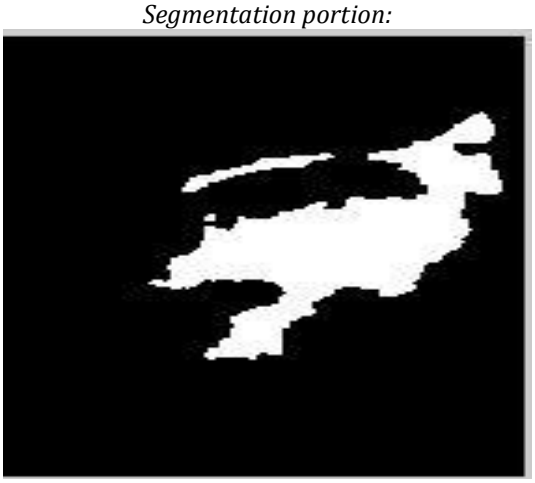
The next step deals with segmentation. Segmentation divides an input image into its small constituent fragments or objects. In general, self-directed segmentation is one of the most difficult tasks in digital image processing. On the one hand, a rough segmentation procedure brings the process a long way towards the successful solution of an imaging problem. On the other hand, weak or unreliable segmentation algorithms almost guarantee eventual failure.[3]

Image segmentation splits an image into its constituent parts or objects. The segmentation should end when the objects of interest in an image have been isolated.

Segmentation:



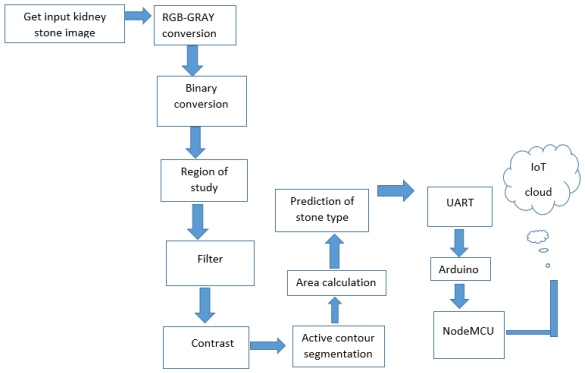
Segmentation portion:



5. IMAGE PREPROCESSING

Preprocessing usually deals with methods for enhancing contrast, removing noise, and isolating regions whose texture show a possibility of alphanumeric information.[7]

Block diagram

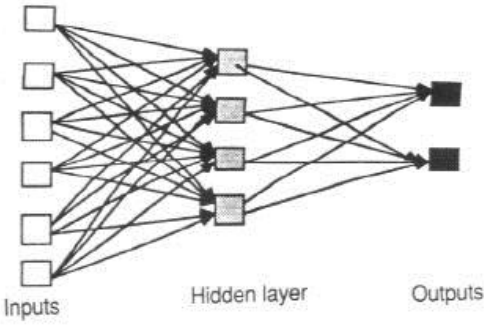


5.1 Active contour segmentation:

In general, there are two kinds of active contour models: edge- and region-based. Edge based active contours apply an edge detector, usually based on the image gradient, to trace the boundaries of sub-regions and to draw the contours to the detected boundaries. Edge-based approaches are related to the edge-based segmentation. Region-based approaches are linked to the region-based segmentation.

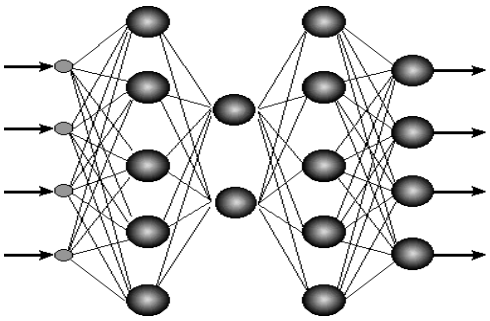
6. NEURAL NETWORKS

An Artificial Neural Network (ANN) is an information processing model that is stimulated by the way biological nervous systems, such as the brain, process information. It is composed of a huge number of interconnected processing elements working in accord to solve specific glitches. ANNs, like people, learn by example. An ANN is constructed for a precise application, such as pattern recognition or data classification, through a learning process. In biological systems, learning encompasses adjustments to the synaptic connections that exist between the neurons. ANNs work in a similar manner.[4]

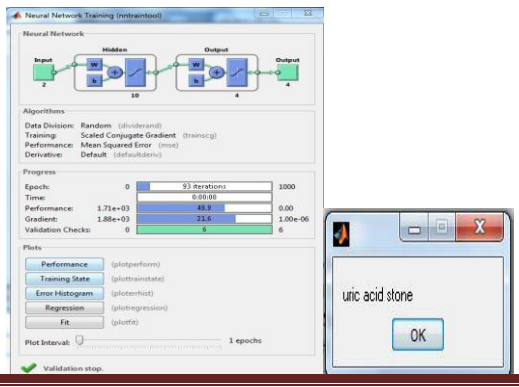


Artificial neural network contains three groups, or layers, of units: a layer of "input" units is connected to a layer of "hidden" units, which is connected to a layer of "output" units.

The motion of the input units represents the raw information that is fed into the network. The activity of each hidden unit is determined by the activities of the input units and the weights between the input and the hidden units. The action of the output units depends on the activity of the hidden units and the weights between them. The hidden units are free to make their own representations of the input. The weights between the input and hidden units define when each hidden unit is active, and so by altering these weights, a hidden unit can be modified.



Obtained result:



Cloud:

Cloud is a term relating to accessing computer, information technology (IT), and software applications through a network connection, by accessing data centres using Internet connectivity. Nearly all IT resources can live in the cloud: A software program or application, a service, or an entire infrastructure.

The entire details of the stone type are sent to the cloud, including the symptoms and remedies. This can be referred by the doctors and patients alike, so that the entire diagnosis is an automated one, completely eliminating the need for human intervention. [5]The different stone types along with its symptoms and remedy is given below:

Kidney stone type [chemical formula]	Specification/appearance	Risk factors	Crystal shape in urine	Remedy
Calcium oxalate (75 %) [$CaC_2O_4 \cdot H_2O$]	Black, gray, white and small, dense, and sharply circumscribed	Low urine volume, hypercalciuria, hyperuricosuria	Envelope	• potassium citrate • diuretics
Uric acid (10 %) [$C_5H_4N_4O_3$]	Spherical with a smooth yellow–orange surface. The interior of the stone appears as orange concentric rings.	Hyperuricosuria, low urine pH, low urine volume,gout.	Diamond or barrel	• Allopurinol • Potassium citrate
Struvite or triple phosphate (10 %) [$MgNH_4 \cdot PO_4 \cdot 6H_2O$]	White concentric rings, and occasionally with white porous granulated material.	Urinary tract infection (urease splitting organism)	Coffin-lid	• antibiotics, which are bacteria-fighting medications • acetohydroxamic acid, a strong antibiotic, used with another long-term antibiotic medication to prevent infection
Cystine (1 %) [$C_6H_{12}N_2O_4S_2$]	Greenish-yellow, flecked with shiny crystallites, with a rounded appearance.	Rare genetic disorder, autosomal recessive disorder	Hexagonal	• mercaptopropionyl glycine • potassium citrate

VII.CONCLUSION:

Deep-learning models were trained using DNN for the purpose of stone segmentation and classification of stones. This task is mandatory for the diagnosis of stones and its treatment. This system is almost equivalent to that of diagnosis by a clinical pathologist.

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