Screening Liver tumor with 3D-IRCAD, ResUNet Model

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Abstract - Our project is designed for screening of the liver to detect tumor. When the liver cells begin to grow from the normal level, they can transform into a tumor. According to WHO, it is the fifth most common type of tumor in men and the ninth most common type of tumor in women as per the study of 2018. The interpretation techniques of CT scans are manual and subjective and therefore they have high chances of errors. On the other hand, MRI is available, and it helps in diagnosis by utilizing advanced surveillance, but it is expensive and has many associated side effects at the time of screening. Moreover, for complex types of liver tumors, MRI is unable to diagnose. Unlike the traditional type of screening methods, Convolution Neural Networks (CNNs) can provide support for deep learning to recognize liver tumors. The performance of CNNs is impressive, in some cases, it has even surpassed the expertise of humans in radiology from the past many years. Our solution is based on screening liver tumors with 3D-IRCAD, ResUNet Model. It takes 2D Image of the CT Scan and the heat map and uses 2 different machine learning models which enables early detection of tumors in the liver. It also generates a 3D Cad model of the CT Scan using the 2D Image and heat-map. Using machine learning models, we are detecting the liver portion in the CT scan of the abdomen. Then using another model, we are detecting the tumor part in the parts of the liver. We have collected our dataset from IRCAD Research Institute against digestive cancer, that has 3D CT-scans of 10 men and 10 women within 75% of the cases. The proposed technique has been trained on kaggle GPU. The result showed the segments of tumors in defective liver images with accuracy and efficiency. CNN provides efficient results in the detection of small size tumors encoding and decoding small information from segments. The examination has been done on a pixel-to- pixel premise. To assess the outcome accuracy, we applied the assessment measurements to binary classification of the confusion matrix. After training the model, we have seen an accuracy of 98.6% on the image dataset and 96% on the 3D RealCT dataset. In future this solution can be used to detect and do early prediction for multiple problems in similar cases for human body parts.

Keywords- **CT Scan, Liver Tumor, Liver cancer, Tumor screening, 3D Simulation, Liver Scan, Machine learning in diagnosis, early prediction of the disease**

1. Introduction:

As we all know Liver cancer because of tumors is widely spread and affects both men and women around the world. CT scan of the abdomen gives information about the size, shape, and location of any type of tumor in the liver area or nearby blood vessels. Its shortcoming is that it can screen only 2nd and 3rd stage Liver Tumor.

Liver sits in the upper right portion of your abdomen, beneath your diaphragm and above your stomach. Several types of cancer can form in the liver. Liver lesions are groups of abnormal cells in your liver. Your doctor may call them a mass or a tumor. Noncancerous, or benign, liver lesions are common. They don't spread to other areas of your body and don't usually cause any health issues. But some liver lesions form as a result of cancer. The most common type of liver cancer ishepatocellular carcinoma, which begins in the main type of liver cell.

In its early stages, liver cancer may not show any apparent signs and symptoms. Over time, though, as a tumor in the liver grows, a patient may see or feel it. Or a doctor may see or feel it during a checkup

What is a tumor?

Tumors are abnormal masses of tissue that form when cells begin to reproduce at an increased rate. Both noncancerous (benign) and cancerous (malignant) tumors can develop in the liver.

What are noncancerous liver tumors?

Noncancerous (benign) tumors are quite common and usually do not produce symptoms. Often, they are not diagnosed until an ultrasound, computed tomography scan, or magnetic resonance imaging scan is performed. There are several types of benign liver tumors, including the following:

● Hepatocellular adenoma. This benign tumor is linked to the use of certain drugs. Most of these tumors remain undetected. Sometimes, an adenoma will rupture and bleed into the abdominal cavity, requiring surgery. Adenomas rarely become cancer.

● Hemangioma. This type of benign tumor is a mass of abnormal blood vessels. Treatment is usually not required. Sometimes, infants with large liver hemangiomas require surgery to prevent clotting and heart failure.

What are cancerous liver tumors?

Cancerous tumors in the liver have either originated in the liver (primary liver cancer) or spread from cancer sites elsewhere in the body (metastatic liver cancer). Most cancerous tumors in the liver are metastatic.

What is hepatoma (primary liver cancer)?

Also called hepatocellular carcinoma, this is the most common form of primary liver cancer. Chronic infection with hepatitis B and C increases the risk of developing this type of cancer. Other causes include certain chemicals, alcoholism, and chronic liver cirrhosis.

Liver (Hepatocellular) Cancer Screening Key Points

● The interpretation techniques of CT scans are manual and subjective, Moreover, they have high chances of errors. On the other hand, MRI is available, and it helps in diagnosis by utilizing advanced surveillance, but it is highly expensive and has many associated side effects during the stage of the screening. Moreover, for complex types of liver tumors, MRI is unable to diagnose.
● Tests are used to screen for different types of cancer when a person does not have symptoms.
● There is no standard or routine screening test for liver cancer.
    ○ Ultrasound
    ○ CT scan
    ○ Tumor markers

● Screening tests for liver cancer are being studied in clinical trials.

2. LITERATURE REVIEW

Presently there is only one main way that Doctors and surgeons use to diagnose the Liver tumor or cancer

Diagnosing liver cancer

Tests and procedures used to diagnose liver cancer include:

Blood tests. Blood tests may reveal liver function abnormalities.

Imaging tests. Your doctor may recommend imaging tests, such as an ultrasound, CT and MRI.

Removing a sample of liver tissue for testing. Sometimes it's necessary to remove a piece of liver tissue for laboratory testing in order to make a definitive diagnosis of liver cancer. During a liver biopsy, your doctor inserts a thin needle through your skin and into your liver to obtain a tissue sample. In the lab, doctors examine the tissue under a microscope to look for cancer cells. Liver biopsy carries a risk of bleeding, bruising and infection.

Determining the extent of the liver cancer

Once liver cancer is diagnosed, your doctor will work to determine the extent (stage) of the cancer. Staging tests help determine the size and location of cancer and whether it has spread. Imaging tests used to stage liver cancer include CTs, MRIs and bone scans.

There are different methods of staging liver cancer. For example, one method uses Roman numerals I through IV, and another uses letters A through D. Your doctor uses your cancer's stage to determine your treatment options and your prognosis.

Computed Tomography (CT or CAT) Scan of the Liver and Biliary Tract:

Computed tomography (CT scan or CAT scan) is a noninvasive diagnostic imaging procedure that uses a combination of X-raysand computer technology to produce horizontal, or axial, images (often called slices) of the body. A CT scan shows detailed images of any part of the body, including the bones, muscles, fat, and organs. CT scans are more detailed than standard X-rays.

CT scans of the liver and biliary tract (the liver,

gallbladder, and bile ducts) can provide more detailed information about the liver, gallbladder, and related structures than standard X-rays of the abdomen, thus providing more information related to injuries and/or diseases of the liver and biliary tract.
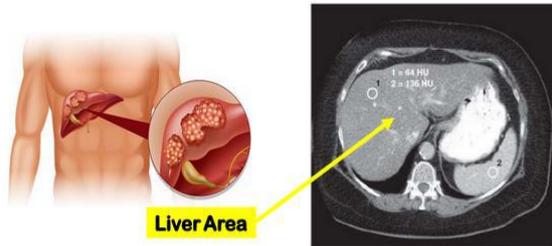
CT Scan of the Liver

CT scans of the liver and biliary tract may also be used to visualize placement of needles during biopsies of the liver or during aspiration (withdrawal) of fluid from the area of the liver and/or biliary tract. CT scans of the liver are useful in the diagnosis of specific types of jaundice (yellowing of the skin and eyes as a result of certain conditions of the liver).
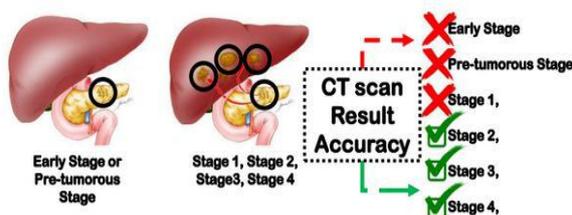
Other related procedures that may be used to diagnose liver and biliary tract problems:

Abdominal X-Ray:
X-rays use beams of energy that pass-through body tissues onto a special film and take a picture. They show pictures of your internal tissues, bones, and organs. Bone and metal show up as white on X-rays.

X-rays of the belly may be done to check the area for causes of abdominal pain. It can also be done to find an object that has been swallowed or to look for a blockage or a hole in the intestine.

Abdominal X-rays may be taken in the following positions:

- Standing up
- Lying flat with the exposure made from above
- Lying flat with the exposure made from the side of the patient

- The left side-lying position may be used for

people who can't stand up

When 2 or more of these views are taken, the set of films may be called an obstruction series. This series of X-rays is done to try to locate a site of an intestinal or abdominal blockage.

What are the risks of an abdominal X-ray?

If you are pregnant or think you may be pregnant, you should tell your healthcare provider. Being exposed to radiation during pregnancy may lead to birth defects.
There may be other risks depending on your specific medical problem. Be sure to discuss any concerns with your healthcare provider prior to the procedure.
Recent barium X-rays of the abdomen or belly may affect the accuracy of an abdominal X-ray.

liver Scan:

A liver scan is a specialized radiology procedure used to examine the liver to identify certain conditions or to assess the function of the liver. A liver scan may also be used to follow the progress of treatment of certain conditions. This procedure may also be referred to as a liver-spleen scan because the spleen often is examined as well due to its proximity and close functional relationship to the liver.

A liver scan is a type of nuclear medicineprocedure. This means that a tiny amount of a radioactive substance is used during the procedure to assist in the examination of the liver. The radioactive substance, called a radiopharmaceutical or radioactive tracer, is formed by the addition of a radioactive atom (radionuclide) to a molecule absorbed by normal liver tissue. The remainder of the radioactive substance is absorbed by the spleen and bone marrow.

The radionuclide used in liver scans is usually a form of technetium. Once absorbed into the liver tissue, the radionuclide emits a type of radiation, called gamma radiation. The gamma radiation is detected by a scanner, which processes the information into a picture of the liver.

By measuring the behavior of the radionuclide in the body during a nuclear scan, the doctor can assess and diagnose various conditions, such as tumors, abscesses, hematomas, organ enlargement, or cysts. A nuclear scan may also be used to assess organ function and blood circulation.

What are the risks of a liver scan?

The amount of the radionuclide injected into your vein for the procedure is small enough that there is no need for precautions against radioactive exposure. The injection of the radionuclide may cause some slight discomfort. Allergic reactions to the radionuclide are rare but may occur.

Patients who are allergic to or sensitive to medications, contrast dyes, or latex should notify their doctor.

If you are pregnant or suspect that you may be pregnant, you should notify your health care provider due to the risk of injury to the fetus from a liver scan.

If you are lactating, or breastfeeding, you should notify your health care provider due to the risk of contaminating breast milk with the radionuclide.

Abdominal Ultrasound:

An abdominal ultrasound is a noninvasive procedure used to assess the organs and structures within the abdomen. This includes the liver, gallbladder, pancreas, bile ducts, spleen, and abdominal aorta. Ultrasound technology allows quick visualization of the abdominal organs and structures from outside the body. Ultrasound may also be used to assess blood flow to abdominal organs.

Ultrasound uses a transducer that sends out ultrasound waves at a frequency too high to be heard. The ultrasound transducer is placed on the skin, and the ultrasound waves move through the body to the organs and structures within. The sound waves bounce off the organs like an echo and return to the transducer. The transducer processes the reflected waves, which are then converted by a computer into an image of the organs or tissues being examined.

What are the risks of abdominal ultrasound?

There is no radiation used and generally no discomfort from the application of the ultrasound transducer to the skin.

There may be risks depending on your specific medical condition. Be sure to discuss any concerns with your doctor prior to the procedure.
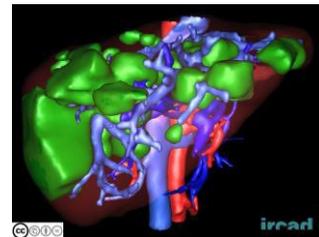
3. Our Solution:

Screening Liver tumor with 3D-IRCAD, ResUNet Model

To overcome disadvantages of current methods, we have developed a screening method that can detect small size tumors in the early-stage like pre-tumorous or in the early-1st stage cancer

through the 3D-CT-scans itself. Our ML model will screen and predict tumors even if they are smallest like a spot.

As we have found that the traditional methods which provide subjective analysis, Convolution neural networks(CNN) can provide us with useful data to create a model that can predict the tumor with the help of the dataset provided to create the model. The performance of CNN can be very impressive as in many cases it has provided more than 95% Accuracy and it has even provided more reliable results than human expertise.

These types of smart Machine learning algorithms and solutions are very commonly used nowadays in the medical field for multiple purposes like laboratory experimentations, Diagnosis, screening and even tracking the recovery and the condition. In our solution we are using CNN as a programmed feature extractor. We are applying it on the pixel data of all the images in the data set to extract the features. It utilizes contiguous pixel data to viably down sample the images first by convolution and afterward utilizes a forecast layer toward the end. In this way we can even detect small size tumors. Along with this we are using ResUNet which helps in simplifying the work for CNN

2D CT SCAN   3D IRCAD

In this project we are using 2D CT SCAN images and creating 3D IRCAD images of that.

Our solution incorporates CNN model which uses terminology of ResUNet model in order to extract all the features from the 3D CT Slice Data.

The feature extraction is a crucial part for test set creation of any machine learning algorithm. This project uses part of pixel vector analysis along with Heat-Map and ROI - Region of interest to

extract the features from the CT slice input data. Post that data is transferred to the AI model which is coded with python3.6.5rc1 version on Kaggle platform.

The Res-U-Net Model is the combination of Residual and Universal darknet model which enables us to spot small changes in input data using CNN deep layers such as Relu-5, Activation-1024, Dense-2.

With the help of this method pre-tumorous spots can be detected easily.

The model is trained with 200 epoch size, which gives best accuracy with test data (T) and Real Time data (RT).

Lastly, the model generates results in terms of confusion Matrix which includes analysis information in terms of numbers.

Such models are too heavy for a simple device but to incorporate the method we have created a web-app which can get data from CT-Scan machine using USB-OTG which gives 2D or 3D imaging formatted data that can be real time processed on the server which gives us quick results. Another advantage of this method is that updating the system or feature incorporation is much easier.

Method:
This methodology is based on the stages which we utilize to implement our research project of liver tumor diagnosis through CNNs and ResUNet model. The preprocessing method of our algorithm can extract the 99% accuracy of results from testing as well as training data which is freely available on IRCAD dataset site.

The Res-U-Net Model preprocessing algorithm can extract all the necessary information like shape, size, location along with heat-map features and surrounding ROI data.

With the help of such features our Res-U-Net model can firstly do segmentation to find out between liver and non-liver areas. Once the liver area is detected it starts searching for tumors.
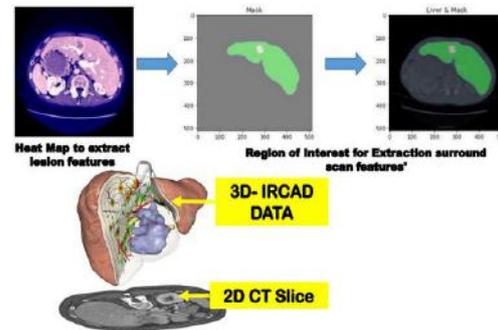

For the dataset feature extraction and pre-training, we have used OpenCV, Heat-Map, ROI and CNN Model respectively. The artificial intelligence Res-U-Net model is used for liver and its tumor segmentation. The model is trained on a 75:35% dataset where 75% is trained data and 35% is test data. Such data contains 2D and 3D CT Scan slice information which is in 2D and 3D Array format. This data is helpful for detection of Tumors in neighboring organs.

Our AI model is formed after a combination of 2 effective models for irregular recognition i.e Residual Network (ResNet) and Universal Network (U-Net) which processes information with handshake protocol. The hidden layers of such models are defined with CNN Algorithm with 32, 64, 64, 512 and 1023 hidden layers. Every node shares 3x3 convolutional blocks with the tumor specific information to the next layer. Lastly the model sends all possible features to a dense function which forms up the output for the liver image using a confusion matrix of 2X2.

Flow Chart:
Our Solution takes a 2d image of the CT Scan and then generates a 3 CAD file of that for better understanding. It does the feature extraction using ROI and heat map. Then after that it applies a machine learning model for liver detection on that and then using that it applies another model for the tumor detection in the liver part in the image.
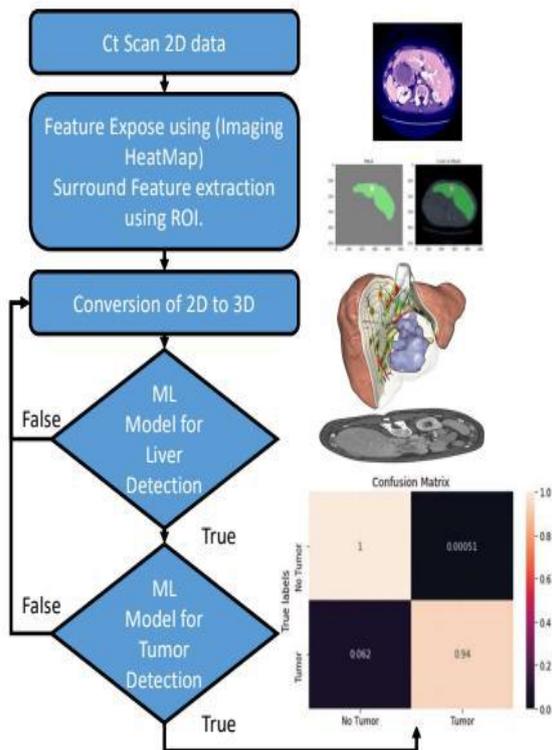
Algorithm

Pre-Processing is done to extract features from the 3D IRCAD dataset, which utilizes Python-OpenCV library to map pixel to pixel features for data dimension transformation from 2D to 3D, along with incorporation of ROI and Heat-Map to extract and expose 99% features of input Trained and Test Data.

Such retrained data is effectively used for detection of liver area and to expose tumor lesions on liver or in neighboring liver organs.

The algorithm first converts 2D slice data into 3D using Python-OpenCV dimension transformation method. Such data is useful to find out liver area from neighborhood organs. The images are analyzed using the in-range function which creates a grey mask on the input gradient image and sends the resulting image for further analysis. This function ranges from -100 to 400 pi intensity per pixel. This analysis is efficient when the color contrast of pixel values is higher than 127. This information is used in DICOM format. Further we apply OpenCV histogram algorithm to equalize to increase the contrast between the liver and its neighboring organs.

The dataset is freely available on the internet "3D IRCAD Dataset" which could have multiple uses, which is well ordered and maintained for public use. This dataset is created by IRCAD Research Institute against digestive cancer, which has 3D CT scans of 20 patients, 10 Men and 10 Women with 75:25% diagnosis ratio. This dataset contains 2D CT images along with 3D Cross Sectional images of 3D CT scan, which produces the entire 3D scan of Scanned Organ. This dataset has about 2800 CT Slice in which all the organs and features are marked as Liver, Bones, Arteries, Kidneys and Lungs etc. This dataset is suitable for the implementation of the Res-U-Net Model.

OUTPUT
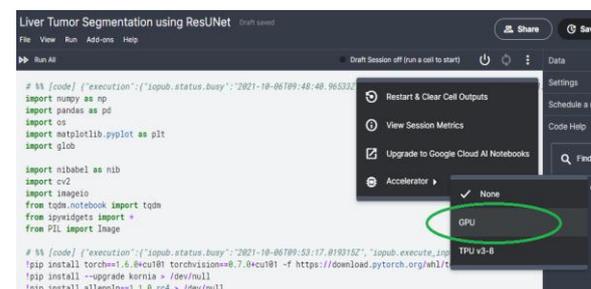
The proposed technique was trained on Kaggle GPU. The result showed the segments of tumors in defective liver images with accuracy and efficiency. CNN provided efficient results in the detection of the smallest size of tumors encoding and decoding small information from segments.
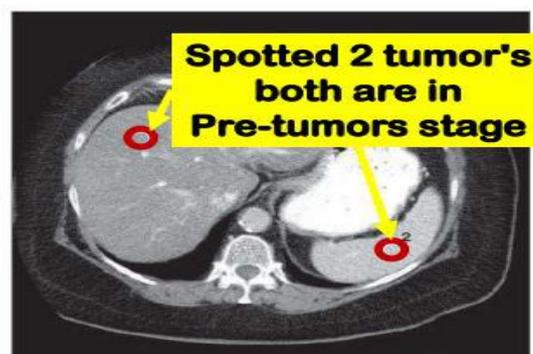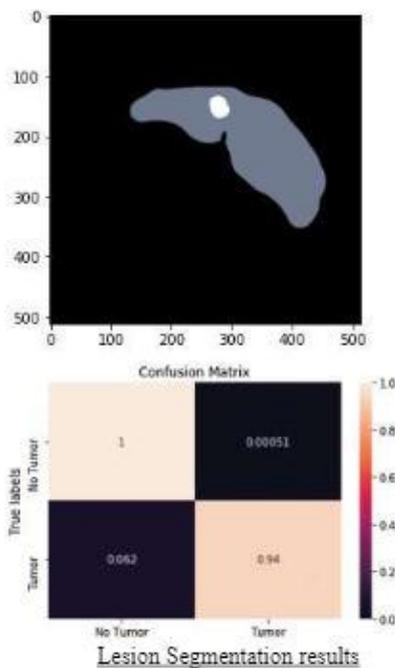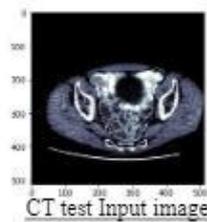

The examination was done on a pixel-to-pixel premise. To assess the outcome accuracy, we applied the assessment measurement as shown below to the binary classification of confusion matrix.

Lesion Segmentation results
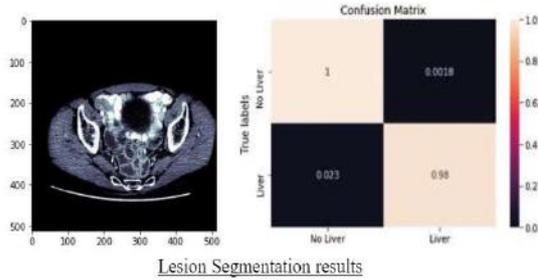
Epoch	Epoch dice coefficient(F1 Score)	Valid dice coefficient (F1 Score)
1	0.86	0.89
2	0.90	0.85
3	0.93	0.91
4	0.94	0.3

By using more datasets and different pre-processing techniques, the efficiency of the ResUNet model can be improved. For the future, it can help to diagnose the small-scale liver tumor with 99.9% accuracy. The value of Validation of Dice Coefficient (F1 Score) is also improved, indicating that the experiment was done successfully and the model is ready to use for the detection of liver tumors.
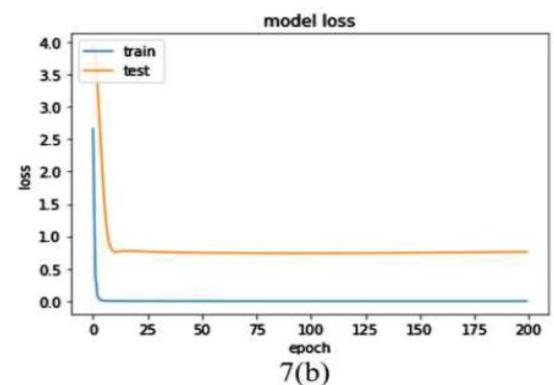

CT test Input image

Lesion Segmentation results

model accuracy

7(a)
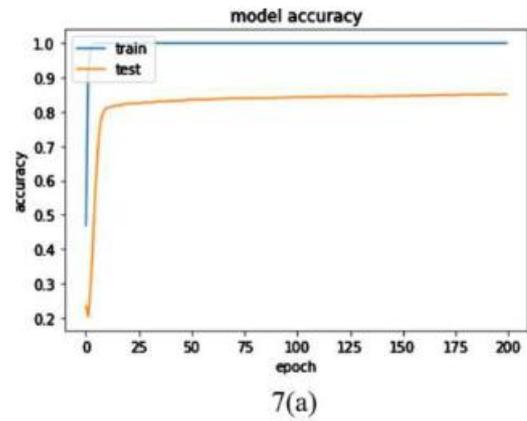
According to the figure 7(a) , this approach shows the accuracy of 98.6% on the test data set

model loss

7(b)

According to the figure 7(b) the performance is 96.3% on the real 3D CT Data

4. Future Scope:

There are a range of improvements that could be made in the future as this is just the beginning of a new approach. Our solution is only focusing on the liver tumor and cancer detection but in the future this solution can be implemented on multiple organs and their CT Scans for example detection of tumor or cancer in the brain by generating a 3D model of the brain, Detecting problems in the kidney, Stomach. It can even help us in detecting problems and condition of lungs in 3D. Using our solution, we can actually do better

diagnosis and screening of any important body part.

It has a really good scope in improving the diagnosis processes and taking them to another level. It can provide early detection of any problem in the liver for now but in future it can help in early detection of any serious problem in the body.

5. Conclusion:

Our solution is basically providing a 3D Graphical visuals of the Ct Scans for better screening of liver to detect the tumor and cancer. It uses 2D images and heat maps. It provides reliable results with very high accuracy

In spite of the fact that the ResUNet demonstrated extremely encouraging outcomes there are a few restrictions as referenced in the limitation of ResUNET. We might have the option to defeat such restrictions via preparing for more epochs, utilizing more information, utilizing distinctive datasets or utilizing diverse pre-processing strategies.

Acknowledgement:

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