Detection of Lymph Nodes Using Centre of Mass and Moment Analysis

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Abstract: In this paper we propose a novel method to determine the spot where the lymph node is present and also analyze whether it causes cancer or not. Lymph nodes are small structures that filter harmful substances. Their incessant growth may lead to cancer. The two dimensional image obtained from CT scan is transformed into three dimensional cube using 3D slicer tool. The center of mass is calculated and moment of inertia is obtained from center of mass. The value of moment of inertia is decreased until a node is detected or it meets a particular threshold. Thus the proposed method enhances the node detection accuracy and reduces the time taken for detection using possible simple mathematical computations..

Keywords: Computed tomography,3D slicer, moment of inertia, moment analysis, 3D virtual view , N-body system , Particle-particle Mesh , centre of mass, centroid , projection plane

1 Introduction

Cancer is a chronic disease which arises when there is abnormal cell growth in particular part of the body. It spreads to other parts if it is left unattended and it may even lead to death. One of the symptoms of cancer is swelling of lymph nodes. Lymph node is a kidney shaped organ and an adaptive immune system. There are several lymph nodes all over the body. Computerized tomography is a technology which is used to scan the body. It generates a two dimensional image of the scanned part. By analyzing the image the swollen and cancer causing lymph nodes are detected and appropriate treatment is given.

There are several ways to analyze the CT scan. As analyzing the two dimensional image is a tedious task, usually the two dimensional image is converted into three dimensional image using any of the existing conversion tool for analyzing it more efficiently**.** A method has to be determined to check the presence of lymph nodes. This method should be efficient such that the lymph node is discovered soon and also in a short period of time. CAD is one such powerful tool to analyze the CT scan images in less time with more accuracy. The main disadvantage of analyzing two dimensional image is that it gives more false positives(FP) when compared to analyzing 3D images.

Hence to overcome the above mentioned disadvantage we devised an algorithm to efficiently detect lymph nodes within a limited time and analyze whether it is a cancer node. The three dimensional image obtained from slicer tool is analyzed for detecting the lymph nodes by taking into account the center of mass and moment of inertia. This method helps to quickly identify the node's location.

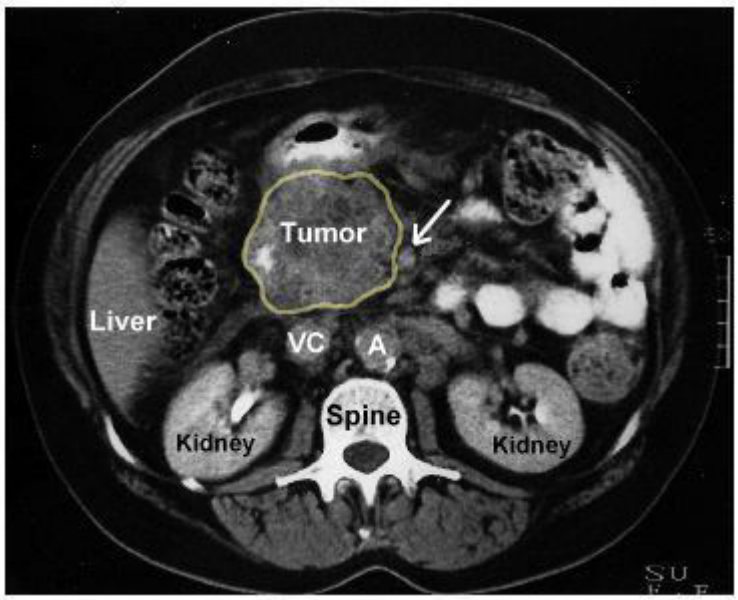


Fig 1: Observation of lymph nodes in different parts of the body

2 Proposed System

In this system, we analyze the scanned CT-Scan image based on the moment analysis. The two-Dimensional image will be taken as an input and placed in a three dimensional cube. The centre of mass for all the six faces of the cube is calculated. At the centre of mass we analyze the node to detect the presence of lymph nodes in three dimensional coordinates. If we find the lymph at the centre of mass then we get the coordinates say x,y,z. If it is not present at the centre of mass then we take the moment of inertia from the centre of mass and the values are stored in array list. After storing values of centre of mass we sort in descending order. Once the table is sorted we check for the lymph nodes presence from the sorted table. At iteration say i, if the lymph node is detected, the coordinates are obtained and it is converted into two-dimensional points.

MOI through axis A = MOI through CG + Md^2

Where:

M is the mass of the object

d is the distance between the CG and the axis A

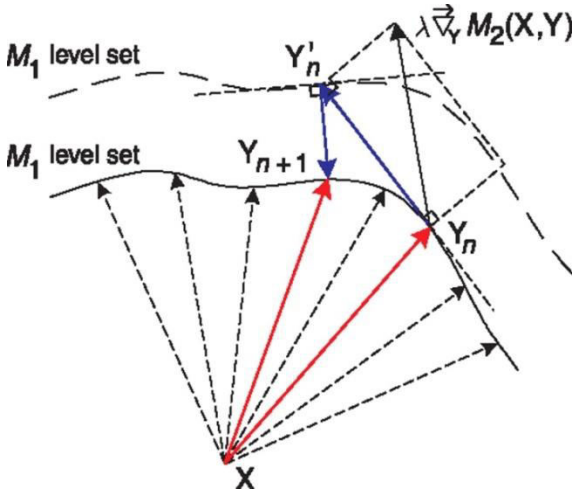


Fig 2: Computing moment of inertia at different coordinates

3 Implementation & Algorithm

The detection process involves conversion of input CT Scan result (2D image in DICOM format) into the corresponding 3D image encapsulated within a 3 dimensional cube. This process is achieved by using the 3D Slicer tool.

The 3D virtual box has the fixed aspect ratios. Also using the fact that the centre of mass of the cube lies in the intersection point of the cube's diagonals, this coordinate centre of mass value is taken as reference point. The centre of mass of each face of the cube is computed separately , leading to the values $r_{cm}(i)$ where i= 1,2,3,4,5,6.

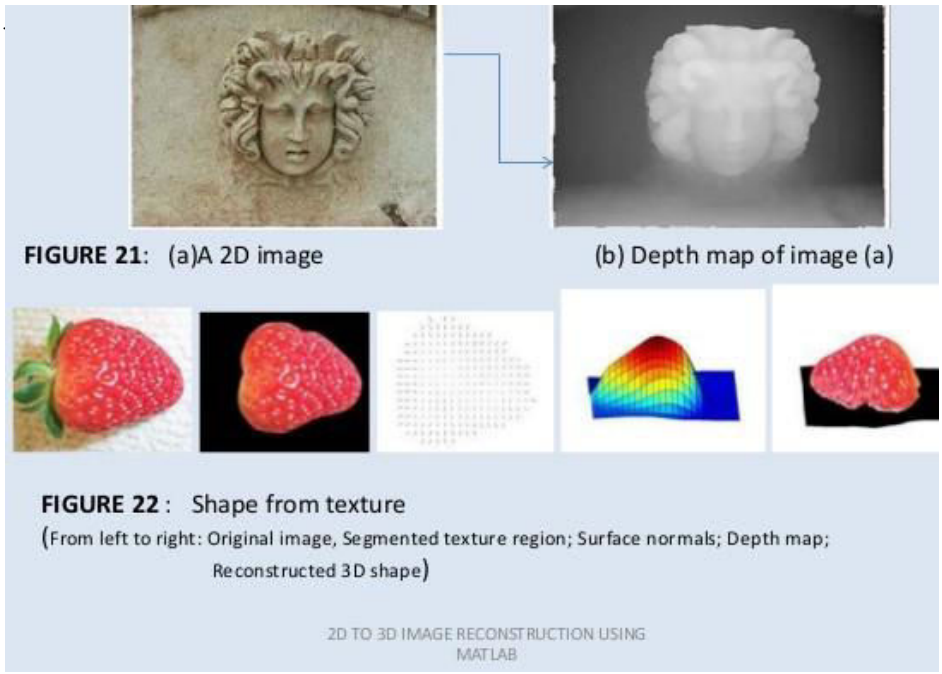


Fig 3: The 2D image encapsulation in 3D virtual box.

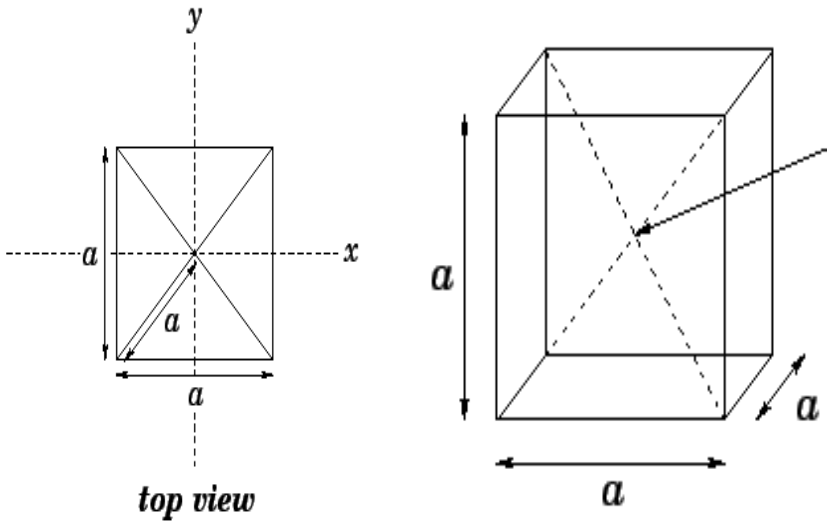


Fig 4: **Initial coordinates using center of mass across different planes**

If the object has net mass M, and is composed of N elements, such that the i^{th} element has mass m_i and position vector r_i , then the position vector of the centre of mass is given by

$$\mathbf{r}_{cm} = \frac{1}{M} \sum_{i=1,N} m_i \, \mathbf{r}_i .$$

Thus the position vector of the 3D cube is the reference coordinate and the position vectors of each face of the cube are mapped around it. If the lymph node is detected at any of the points in the centre of mass in 2D or 3D projection , the corresponding coordinate combinations (all 8 possibilities xyz, yzx , xzy …or all 4 possibilities xy,yx..) are verified and thus the partial result and confirmation of presence of lymph nodes is diagnosed.

If no lymph node is detected at the reference point as well as the 2D face coordinates, then the corresponding moment of inertia is computed for each of the coordinates. The values are used as a dataset arranged in descending order of the moment of inertia value.

3.1 Moment of Inertia Computation :

Nodules are often observed as globular regions, this is used as a distinguishing factor between the nodules and blood vessels, since the blood vessels appear as cylindrical regions. These two-type regions are distinguished based on the moment-of-inertia where voxel intensities are regarded as mass after applying the radial suppression filter. First, a gamma correction is applied to g(x, y, z) as follows:

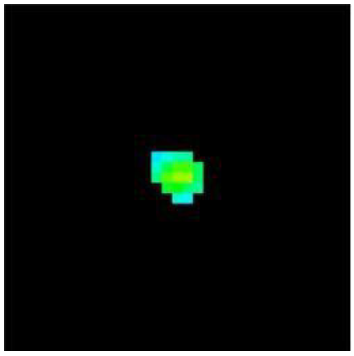
$g\,\gamma\,(x, y, z) = \{g(x, y, z)\}\,\gamma$,

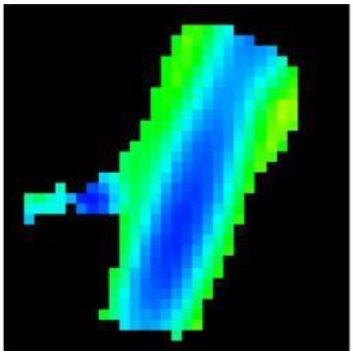
where $g\,\gamma\,(x, y, z)$ is the corrected image, and γ is the parameter of the gamma correction. A moment-of-inertia tensor I is defined by I,

I = [[Ixx Ixy Ixz][Iyx Iyy Iyz][Izx Izy Izz]] , (Array of inertia vectors)

where Ixx = X (x, y, z) ∈ Ksp(rf ix) g γ (x, y, z)(y 2 + z 2),

Iyz = Izy = − X (x, y, z) ∈ Ksp(rf ix) g γ (x, y, z)yz.





Thus for each unique MI value in the dataset , the corresponding coordinates are checked for the presence of lymph node , this is done by using the moment analysis and the SSIM technique.

The task moment can be used to generate moment images from a spectral-line cube. The moment axis should be either the first or third in the cube (e.g. vxy or xyv order). Reorder if the moment of the second axis is required for some reason. The moments (evaluated for each spatial pixel and along the velocity axis) are defined as

$$M_n = \int I(v) v^n dv$$

where I(v) is the intensity at a given velocity v.

The overall functioning of the system can be summarized as shown in the block diagram below :

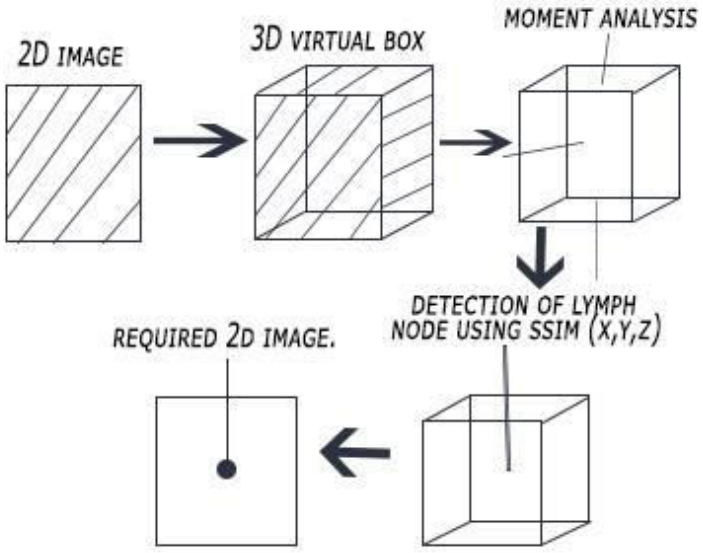


Fig 5: The process flow for detection of lymph nodes

Translation of 3D space coordinates to 2D coordinates :

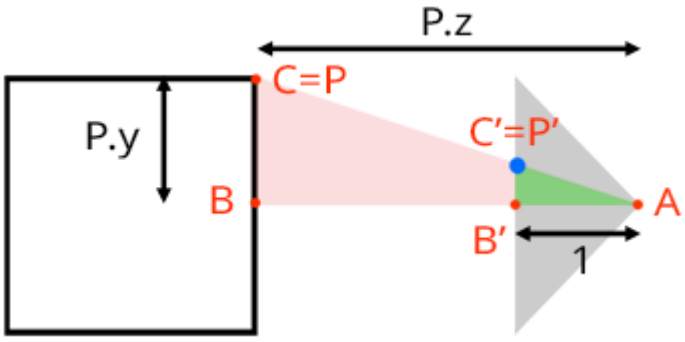


Fig 6: Mapping of 3D to 2D coordinates

P′.y=P.y/P.z ; P′.x=P.x/P.z

The particle-particle approach is used to detect the next neighboring lymph node.

4 Conclusion

The proposed method can be used to detect and analyze the lymph nodes which may lead to cancer. As center of mass and moment of inertia are taken into consideration for detecting the presence of lymph nodes, this makes it simpler and efficient to detect the location of the node. This reduces a lot of time to spot the exact location of the node. Since three dimensional images are used for analyzing the presence of lymph node it gives more accurate results.

5 References

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