ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Design, and development of basic vision module of an industrial ABB IRB1410 Robot

Indrani Sanyal*, A. Vijaya
Department of Mechanical Engineering, Robotics, SRM University, Kattankulathur-603203, Tamilnadu, India.
***Corresponding author: E-Mail: indrani.sanyall@gmail.com**

ABSTRACT

This paper is aimed at basic design and development of 3D vision module for ABB Industrial Robot. The vision module utilizes multiple images of the object and a 3D model reconstruction is done using the images developed and exhibited in matlab. Here the object of interest is placed in front of the robot and a camera is fixed to the manipulator to take images at varied angle. The algorithm that is used here is simple and can be used for real time frames. The image shows any notable colour difference if there is a defect in the object and according to the colour change we can find the depth of the object. It utilizes multiple numbers of images of the object and a 3d reconstruction is done from those using matlab and object parameters are obtained after many consecutive trials. In this project simple objects are taken for experiments but can be used for more complex objects.

KEY WORDS: Vision module, 3D reconstruction, ABB manipulator, Matlab, Voxelisation.

1. INTRODUCTION

The paper is aimed in using a robot that obtains photographs of a given object from known angles which is fixed in front of it. These 2d images are modelled to obtain the 3d form of the object, which is developed and exhibited in matlab. Thus the project is not limiting itself to give the user the freedom of viewing the object at any angle and orientation but provides with the complete model in space. This paper focuses the software part as well as the implementation of the algorithm with the help of ABB manipulator. Application of 3d vision includes automated navigation, tracking and interpretation of motion, face recognition and 3d modelling. It is also used for inspection, object identification, visualization and defect detection purposes.3D reconstruction is a complete process that starts with data acquisition and ends with a 3d virtual model interactive on a computer. The general classification can be divided into contact and non-contact methods. Non-contact methods are used more frequently with active or passive sensors. Active sensors provide the range data directly containing the 3D coordinates. Passive sensors, on the other hand, provide images that need further processing to derive the 3D object coordinates. Then the data is structured and a consistent polygonal surface is then created. A photorealistic visualization is then generated by texturing the virtual model with image information. A lot of research has been done in this field and a large number of algorithms are proposed. One of the direct method is selected for a correct set of reference points among all image points. Both calibration and reconstruction are incorporated in the same optimization process. Volumetric methods are suitable for objects with smooth surfaces where matching process is not required between the images. Voxel coloring was the first method to use a color consistency measure. Some methods use a perspective camera model which are portable and low cost to recover 2d information through a mathematical model or methods such as shape from shading, shape from contour and shape from 2d edge gradient. SIFT is used nowadays for object detection which involves finding keypoints by using Gaussian matrix. But all these processes are very time consuming and calibration errors exit.

2. MATERIALS AND METHODS

This section presents the overall overview of the working of the vision module. It consists of three steps. First step is algorithm selection where an algorithm is selected which works with real time is selected and implemented in matlab to construct a 3d image. It basically generates a database of continuous object of discrete digitization. The second step is the selection and design of sensor geometry. Here a camera of required specification needs to be interfaced to the robotic manipulator. The object of interest is fixed in front of the robot. The images of the object will be obtained using the single camera at varying fixed angle. Number of images depends on the complexity of the object. The third step is the system integration and implementation. In this phase all the components are interfaced and proper functioning of the algorithm is checked. Structuring modelling texturing and visualization of the model is done in this phase.

Algorithm: The algorithm selected utilizes the concept of voxelisation which is also called as 3D scan conversion process as it replicates the scan–conversion process that rasterizes or pixelises the objects of 2d geometries. It is fast and resources required is less while using this algorithm. In this the first step is acquisition of data. In this step images are acquired first for further implementation of the algorithm. Here a monocular camera is used for taking images of the object from different angles but the difference between the angles should be constant. Second step in preprocessing. Enhancing the data images before any processing is called image preprocessing. It can also be referred as removal of low frequency background noise. There can be salt and pepper noise, guassian noise and different other types of noises in an image. Filters based on applications is used for removal of noise. Third step is separation. Here region of interest, i.e. the desired object is separated from the background so that mapping can be done on that.

This process involves simple thresholding and cropping the region of interest. Here the image is converted to grey scale image such that the source image reflect its contrast thus object details are retained. The fourth step is mapping and rendering where 3d object is modelled by using voxelisation. Two images is the minimum requirement for this process. So if img1 and img2 be the two images and image N (width, height) be the pixel in specific location. Let mat3d be the matrix of the 3d image mapped. Then width of the img1 is counted, height of img1 is counted and width of img2 is counted. If the pixels in the position of first count and third count of img1 is same as the pixel in the position of third count and first count of Img2 then pixel position of img1 is stored in mat3d otherwise it is left empty. The obtained 3d matrix is then rendered to voxels.

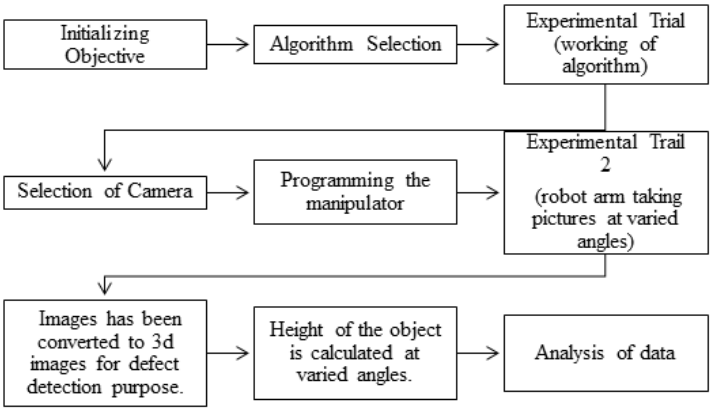

Fig.1.The General System Structure

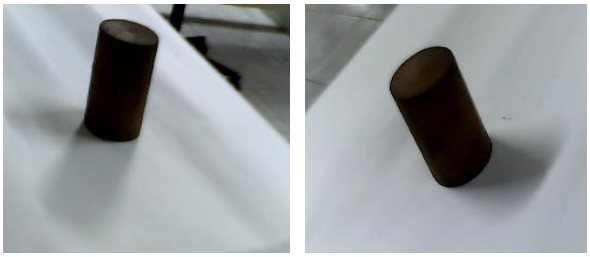

Fig 2: Image Pair 4

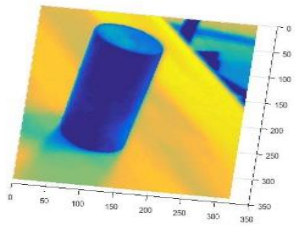

Fig 3: Output of image pair 4

The Experimental Setup: The general structure can be seen in fig 1. Each of the steps will be described briefly in this section so as to give a general idea of how the project is structured. The first phase in this project is the determination of the algorithm. Working of the algorithm is checked using some real time images in the robotics lab. The second phase comprises working with the robotic manipulator which in this case was an ABB IRB1410 manipulator. The object of interest was kept in front pictures were taken at specific angles and distances and 3d reconstruction was done and the geometric properties were obtained.

A normal web camera is used in this project which is attached to the gripper such that it is aligned with the middle axis. Object of interest was placed in front of the robot exactly aligning the same axis and within the working range of the robot.

The object of interest is placed in front of the robot and a camera is fixed to the manipulator to take images at varied angle. It utilizes multiple numbers of images of the object and a 3d reconstruction is done from those using matlab and object parameters are obtained after many consecutive trials. At first set of two images are captured and a reconstruction is done and similarly again sets of four images are taken and reconstruction done and the height is obtained.

3. RESULTS AND DISCUSSIONS

Two images were captured by the ABB manipulator at different angles and reconstruction was done and height of the object was calculated. Among those images four pairs of images are shown with their data that were obtained during the experiment. Fig 2 is a pair of image that was captured and fig 3 is its output. Then obtaining the data from ABB height of the object is calculated which is shown in table 1. Similarly the rest of the data follows in table 1.

The table 1 tabulates the result obtained after taking images of the desired object from various angles. Here two numbers of images are taken for reconstruction. Image set 1 corresponds to fig 2 and its output is shown in fig 3. Similarly other image sets are related. Manipulator angle (θ) plays an important role as it helps to find the distance. Here the camera orientations (α) are taken at a range of 48 to 60 degrees. So in order to get minimum error we need to optimize it correctly by taking n number of images. In the next trials we consider four images and data is tabulated

and corresponding height and error is found. So a set of four images were captured and a reconstruction was done accordingly. Some of the images are not reconstructed properly because of some capturing angle problem. So consecutive pictures were taken as a set of four and its geometric parameter value was obtained and was analysed. The table 2 shows the datas that were obtained.

In the table 2 four image data set is shown. Here four images were taken for reconstruction and object parameter was obtained. The error percentage here is more. This is due to the fact that images were taken at random angles in the same plane around the object and angle of orientation of camera between two images were not same. This drawback was eliminated in the subsequent section where again four sets of images were captured and reconstruction was done and data was analysed.

In the table 3, data from four set of images are tabulated. Here manipulator angle (θ) plays an important role as can be seen in the table data. Camera orientation angle (α) is again adjusted at a range of 48-60 degrees. Images were taken at an angle not fixed but varied between 43-55 degrees. The reconstruction was done and object parameter which in this case is height is found with an error reducing to 1%. So by taking proper angle which includes all the three angles error can be minimized.

Manipulator angle (θ), camera orientation (α) and camera image angle, all play an important role for getting the image reconstruction and the desired geometric properties. Images are taken from different angles and data had been analysed.

Fig 4 shows a graph of error estimation of height. Here four data are plotted from the table. As seen from the graph error is minimized for the second data. And the third data also shows a minimal error. So in this case we can say that manipulator angle should be between 30 to 35 degrees to make the error minimum. Here assuming that manipulator angle is varied and other factors remaining constant.

Fig 5 shows a graph of error estimation of height. Here six data are plotted. As seen from the graph error is minimized for the fourth, fifth and sixth data. That is when the angle is between 30 to 33 degrees, then the error is reduced to minimum. Other factors like camera orientations and all play an important role but meanwhile we are assuming that manipulator angle is varied and other factors remaining constant.

So basically to reconstruct an object with abb manipulator we need to fix the angle properly in order to capture the images properly and to get the geometric properties. It is a six axis manipulator so we need to consider those in order to get the position of the camera. Here manipulator angle is considered and varied. Other parameters have been varied in a fixed range. So major influence is the manipulator angle from the home position is considered here.

Table.1. Calculated values of pair of images

Two Image Set	Manipulator angle (θ)	Distance (d) (mm)	Estimated height (mm)	Real height (mm)	Error (%)
Two Image Set 1	28.4	208.5	83.4	98.1	14.9
Two Image Set 2	31.8	254.92	101.41	98.1	3.37
Two Image Set 3	35.4	409	108.7	98.1	10.8
Two Image Set 4	47.9	250.75	117.7	98.1	19.9

Table.2.Calculated values of Four Image Sets

Four Image set	Estimated height (mm)	Actual height (mm)	% Error
Four Image set 1	70.8	98.1	27.8
Four Image set 2	82.96	98.1	15.43
Four Image set 3	105.27	98.1	7.3
Four Image set 4	67.37	98.1	31.3

Table.3.Calculated values of Image Set 2

Four Images Set	Manipulator angle (θ)	Estimated height (mm)	Actual height (mm)	% Error
First set	33.8	107.1	98.1	9.2
Second set	23	85.4	98.1	12.9
Third set	27	87.5	98.1	10.8
Fourth set	30.4	96.1	98.1	2.03
Fifth set	32.3	99.06	98.1	0.98
Sixth set	33	100.36	98.1	2.3

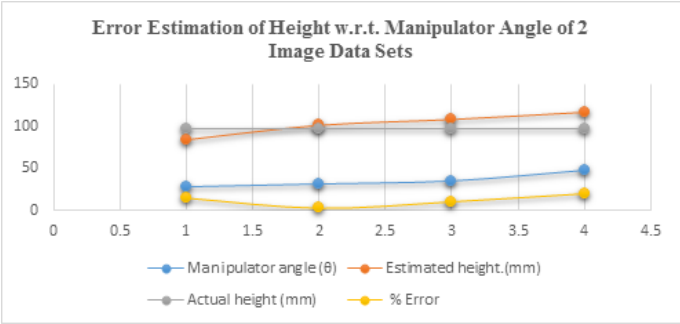

Fig.4.Variation of Error Estimation of Height of 2 Image Sets

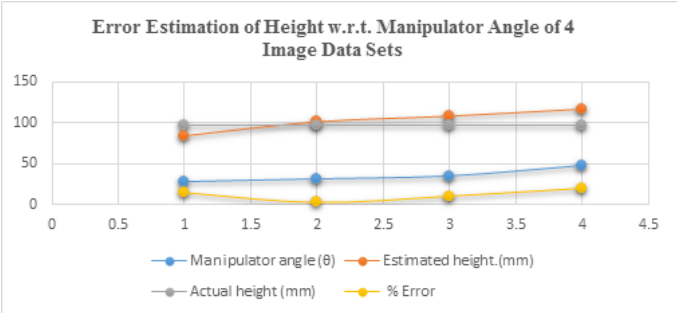

Fig.5.Variation of Error Estimation of Height of 4 Image Sets

4. CONCLUSION

The object reconstruction of the real time images is done in very less time and hence can be used effectively for inspection purpose if limitations are removed. Object parameters are found and the data is analyzed so as to get the accurate result. The disparity image will show any notable colour difference if there is a defect in the object and according to the colour change we can find the depth of the object. The object of interest is placed in front of the robot and a camera is fixed to the manipulator to take images at varied angle. It utilizes multiple numbers of images of the object and a 3d reconstruction is done from those using matlab and object parameters are obtained after many consecutive trials.

Calibrating the Tool Centre Point of the ABB manipulator can give more defined results leading to more accurate 3d reconstruction with more known data. Also other algorithms can be used for more distinct reconstruction.

REFERENCES

Lowe DG, Distinctive Image Features from Scale-Invariant Keypoints, International Journal of Computer Vision, 16(2), 2004, 91-110.

Mohr R, Quan L, Veillon F, Relative 3D Reconstruction Using Multiple Uncalibrated Images, International Journal of Robotics Research, 14 (6), 1995, 619-632.

Pollefeys M, Gool V, Vergauwen M, Verbiest F, Cornelis K, Koch, Visual modelling with a handheld camera, International Journal of Computer Vision, 59 (3), 2004, 207-232.

Seitz S, Dyer CR, Photorealistic Scene Reconstruction by Voxel Coloring, International Journal of Computer Vision, 35(2), 1999, 151-173.

Slabaugh G, Culbertson WB, Malzbender T, Stevens MR, Schafer RW, Methods for Volumetric Reconstruction of Visual Scenes, International Journal of Computer Vision, 57(3), 2004, 179-199.