Application of Target Point Detection Technique for Positioning and Assembling of Ship Blocks

Ronesh Sharma[1] and Seong Ro Lee[2]

[1]Department of Electronics, Mokpo National University, South Korea
[2]Department of Information and Electronics, Mokpo National University, South Korea
[1]sharmaronesh@yahoo, [2]srlee@mokpo.ac.kr

Abstract

This paper presents the algorithm for target point detection using image based methods and sensor networks to monitor the accuracy control for assembling ship blocks in a ship yard area. Dimensional control of the product at all assembling level accounts for a profitable ship production. An accuracy error at each stage accumulates to a higher value which leads to low level of ship productivity. The implementation of the image based method will enhance the monitoring system to increase the ships productivity while reducing the reworks and manual adjustments. To efficiently measure the distance between two ship blocks in real time, sensor nodes are used and the data is transferred to the monitoring server by wireless network. In order to get the correct assembling position of the ship blocks, the target points of the ship blocks to be assembled together are detected and analyzed to decide the next step for the control system. Thus as the distance is received by the server, the next direction of movement is directed through simulation results of target detection and analysis. The final process of shield wedding is done once approved by the end observer.

Keywords: *Sensor networks, Edge detection, Ship blocks Assembling, Ship block monitoring*

1. Introduction

It is very important to implement dimensional control of product at all different assembly stages to drive the industry to a profitable ship production[1]. Block laying method in the shipyards has been in practice for the past years and it has great advantages when compared to the earlier methods. In the process of ship block assembly, two blocks are assembled together while monitoring the manufacturing accuracy control very closely. Besides, if the assembly process or the block turns out to be out of the manufacturing accuracy system, thereby it is being adjusted through welding or extras are being removed. While not having a tight accuracy control leads to loss of materials and increase in labor work which increases the production cost of ship building.

Before in the shipbuilding process experience workers were involved in the accuracy control through use of measuring tapes and with manual observation. Now day's laser optical devise has become common in the measurement and control of products deformation[2]. This laser device can measure the assembling process of ship blocks but manual observation needs to be done and the optical laser has also many restrictions. Lee[2], proposed a system whereby sensor nodes are used for measuring distance between the two ship blocks, and a wireless network to transfer the data from the sensor nodes to the monitoring server and uses an image based processing to correct the positional declination, the data's are analyzed and the next step is processed to further adjust or to perform seam welding between the two blocks. However the approach he took for correcting the positional declination with image acquisition and taking the center view of the camera at the center of the target will need lot of manual adjustment. A more robust application of image acquisition and processing needs to be implemented to decrease the level of manual adjustments. And further not only direct the direction of movement but also the distance of movement.

The development of accuracy control management in ship block assembling process intends to provide an allowable limit of deformation control for typical ship blocks. Han[3] outlined major sources of errors in the ship block assembly which sets a certain criteria for precision management in assembling process. Sensor technology (Hightower and Borriello[4]) showed application of measuring distance between two points using the strength of received signal and time difference of the received signals. Some applications have tried to determine the relative position of sensor node using RFID and UWN or other wireless networks, however errors result to be in meters which is beyond the ship block assembly precision. The assembly of the ship block requires precision to nearest few millimeters. Lees[5] method uses sensor technology, by combining ultrasonic sensors and positional decoders to measure the distance between sensor nodes in the two ship blocks and uses an image based method to correct the amount of positional declination, however his method includes lot of manual adjustments in image method to correct declination. Our method decreases the level of manual adjustments when compared to his; moreover it improves the precision of the blocks assembly process while combining sensor technology with edge detection.

2. Monitoring System for Ship Block Assembly

To monitor the ship block assembly process, Lee[2] proposed the sensor node application to measure the relative distance between the two blocks. For monitoring the ship block assembly process, the design needs two information to determine the next step for assembling. One is the relative distance between the two ship blocks and the other one is the amount of positional declination (is the position gap between the real time and the target position). In order to control the accuracy between two blocks, the distance between the two assembling blocks needs to be measured. Several sensor applications were researched before for measuring distance between two points which are not applicable to ship block assembling due to low level of precision. The ship building process needs sensors of millimeter precision but the sensor developed were of meter precision. Lee[5] came up with the idea of measuring distance between ship blocks with ultrasonic sensors which are very sensitive to the environment and when the ship blocks come close to each other, the result turns to be unreliable due to sensitivity. Lee[2] proposed a system to combine ultrasonic sensors with a linear positional sensor approach to get precision in millimeters. For more reliable monitoring system the correct position of the sensors is required.

In the process of ship block assembly, the ship block needs to be moved in X, Y and Z axis to accurately match its target position. To get the blocks to the target position, Lee[2] proposed the method of positional declination, where selected points are monitored to be exactly at the same position for the two blocks to be assembled correctly. This means considering one block to be fixed and then the other block needs to be given a direction of movement to get in the correct position. He used a digital image based method of capturing the target assembling block to get the next direction of movement to correct the positional declination. However his method involves taking the center of the camera on the center of the circle on the target board, then once the center of the circle is exactly on the center of the camera view, and then no more positional declination is required. His method needs manual adjustment to get the target position on the center of the camera view. There is a need for much more research to remove as much as manual adjustments, even though an end observer is needed for the final decision. Furthermore the above method just indicates the direction of movement and measures the distance between ship blocks. A more robust method needs to be developed to measure the distance between ship blocks with low level of precision, with allocating the next direction of movement and even to calculate the direction of movement distance.

3. Design of Monitoring System using Image Based Method and Sensor Nodes

3.1. The Positioning of Sensor Nodes in the Target Blocks

In the process of monitoring the ship block assembly, the data of the relative distance between the sensor nodes are gathered and transferred to the monitoring server through wireless networks. Figure 1 shows the application of sensor node attached to the ship blocks.

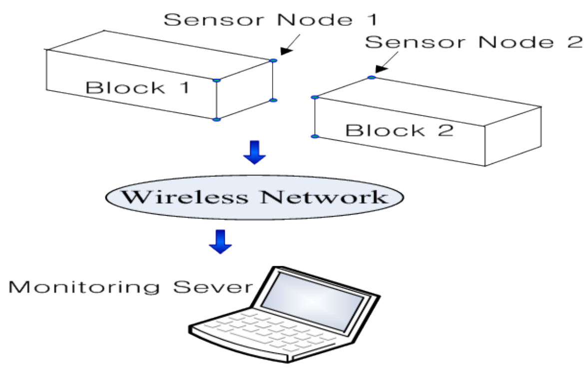


Figure 1. Sensor Network Application Model Attached to the Ship Block

As stated before ultrasonic sensors are very sensitive to the environment and the assembling blocks needs high level of precision in the ship production process. This paper proposes to combine ultrasonic sensors and linear position transducer approach of Lee[5] with image processing application, where the nodes to be assembled together are detected and analyzed from the captured image. The method to detect the nodes from the captured image is described in the method of positional declination. When the distance measured from Lees approach decreases to millimeters, the nodes detected from the image are also monitored for being exactly on same position with low pixel uncertainties. As the measured distance reaches it thresh hold value the monitored nodes should be located at one position for the higher level of accuracy.

3.2. Basics of Positional Declination

In the process of positional declination one block is fixed (block 1) and the other block (block 2) is moved in X, Y and Z axis direction to achieve the correct position of assembly. As shown in Figure 2, the distance D1 between the two nodes is measured and this distance needs to be reduced in order to successfully assemble the two blocks. Considering node 1 and node 2 in 2-D plane and from Figure 2 taking point A as a line perpendicular to node 1 plane, then node 2 needs to be moved in the direction to A in order to reduce the distance between the two nodes. A similar method applies to correct the positional declination in all other axis.

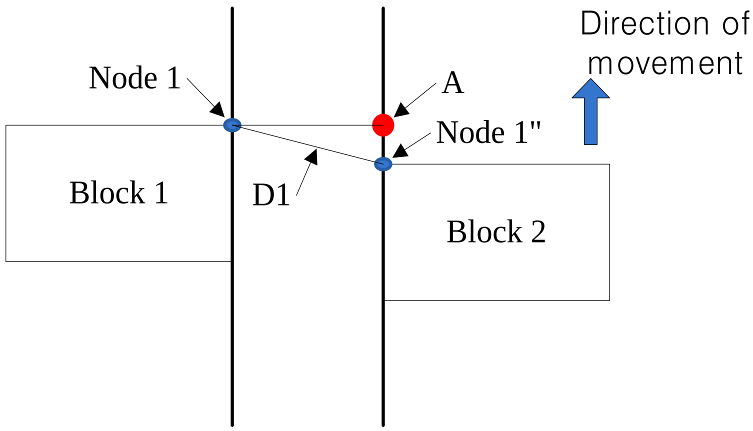


Figure 2. Basics of Positional Declination

3.3. Proposed Method for Correcting Positional Declination by Object Detection and Image Processing Technique

In order to get the positional declination efficiently, a CCD camera is used to capture the target face of the ship block. The target face contains rectangles of blue and red colors. Figure 3 shows the camera system to capture the target face of the blocks.

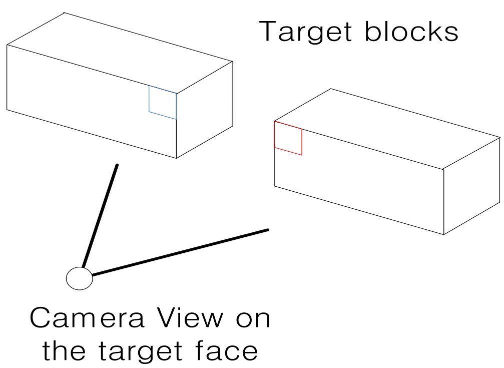


Figure 3. Camera System to Detect the Target Face of the Assembling Blocks

In order to locate the two points (nodes) of the two blocks which needs to be on one exact position for no further declination, the colored rectangle for each block needs to be detected. Once the rectangle is detected, the two nodes can be deduced one for the fixed block and the other one for the moving block. Analyzing the relative distance between the nodes detected, the direction of movement of the blocks can be deduced to correct positional declination. Figure 4 shows some examples of positional declination in the 2-D plane.

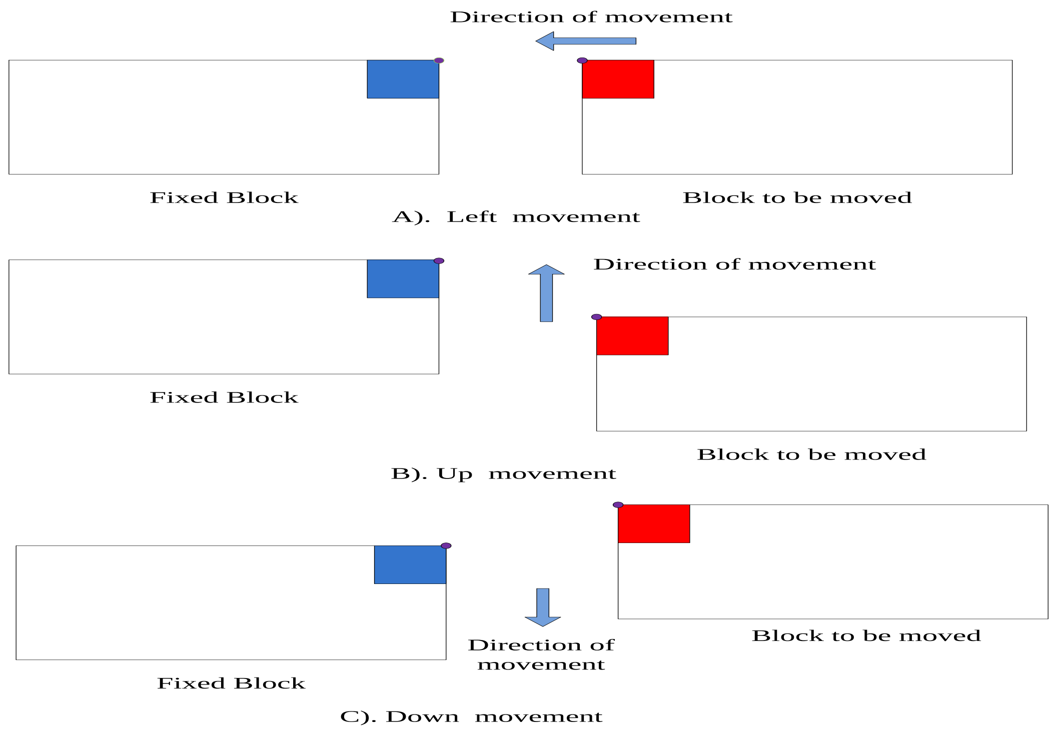


Figure 4. Cases of Positional Declination

The digital Image based method is used to detect the colored rectangle from the captured image. Firstly color edge detection is performed on RGB image, the color edge is deduced and the image is transformed into a grayscale image. Binarization, labeling and chain rule, method is applied to gray level image to find the 90 degree corners of the detected rectangle. Since the target block is captured from the plane view of the target face, from the properties of the rectangle and image, the node points of the two blocks which needs to be assembled together are analyzed. Once the nodes are deduced, by analyzing the corresponding x and y direction relative pixel, the positional declination is calculated by following the process as described before. Figure 5 shows the process of image processing steps.

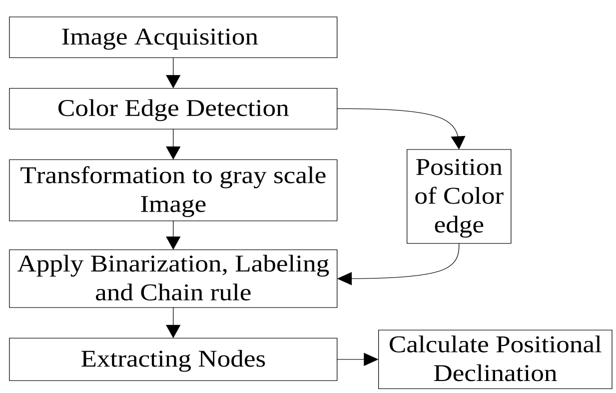


Figure 5. Proposed Image based Method

3.4. Data Gathering and Interpretation

The sensor nodes measures the distance between the assembling blocks and needs to report its distance to the monitoring sever. Applying switch approach of sending measured data in a define interval T, where interval T depends on the rule satisfied by the threshold value of the distances measured. There are number of sensors attached to the assembling ship blocks and if it continuously transforms data it will form a large volume of data, furthermore sensor nodes are power operated, applying a more intelligent method will reduce the large volume of data and will have more robust and efficient system operation.

While measuring distances in the assembling process the sensor nodes will continuously measure the distance between the two ship blocks but it does not need to report distance continuously, for example if the two blocks are apart by 5m, then data is reported every 1 second, it is possible the block will not come close to each other in one second. Thus the reporting time can be much larger than 1 second however if the block comes close to each other the distance needs to be reported more frequently. Therefore a threshold value of the distance needs to be set above which the data will be sent every T1 interval and below which the data will be send at every T2 interval. The rule for assigning the interval time by the threshold value is as follows:

Rule(1): Report Distance(z) In every T1 seconds when Distance(z) <= A1
Rule(2): Report Distance(z) In every T2 seconds when Distance(z) >= A1

The monitoring server will receive the distance data and will interpret in which rule the measured distance fall in the then it will send the corresponding interval time to the required nodes. When two ship blocks are assembled together, several pairs of sensor nodes are attached to the blocks. The sensor nodes continuously measures the distance but only reports the data at the defined interval T1 or T2, which are allocated by the monitoring server. This means that only sensors which fall under the reporting condition will report the distance to the monitoring server. The measuring of positional declination by the edge detection approach reports the position of the two nodes and direction of movement of the moving node. The process of positional declination continues until the two detected nodes are exactly on one position with low pixel uncertainties and the reported distance is in nearest millimeters, which then indicates the end observer to check the assembling accuracy.

3.5. System Structure Implementation

The system structure of ship block assembly needs to be implemented through the method discussed before. The system consist of two phase, one is the data acquisition and the other is monitoring system. The data acquisition subsystem gathers the data and reports it to the monitoring subsystem for the next step to be implemented as discussed before. The system structure is shown in Figure 6. This paper uses Lees[5] sensor approach, ultrasonic sensors to measure the distance between the sensor nodes and reports the distance data to the monitoring server every T seconds interval, where T is satisfied through the rule for threshold distance.

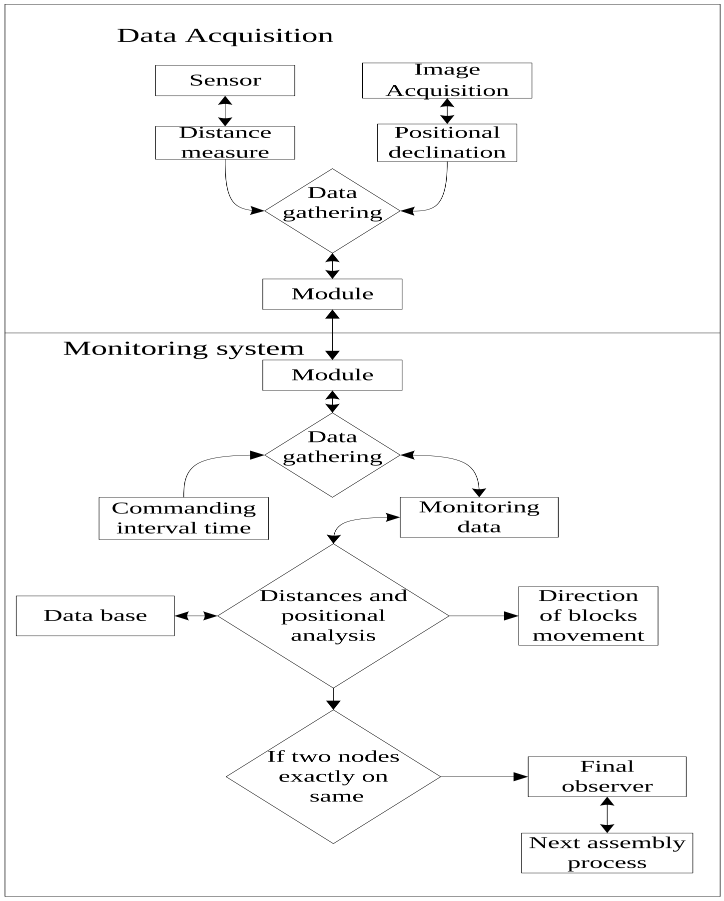


Figure 6. System Structure

4. Simulation Analysis for Edge Detection

4.1. Target Plane Face of the Assembling Block

For real time simulation of the ship block assembly, a small sample of two blocks with target faces with colored rectangle was constructed. The simulation consists of three phases, color edge detection, extracting the node points and analysis of positional declination. Firstly, a computer method was applied to design a sample of two blocks assembling process and to capture its target face. Figure 7 given below shows the captured sample target face of the blocks.

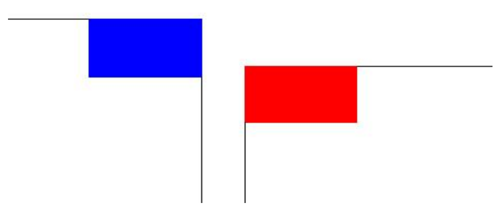


Figure 7. Captured Image of Assembling Block in 2-D Plane

4.2. Color Edge Detection

In order to detect the node points, the position of the colored rectangles of the assembling block needs to be detected. The method uses color edge detection to get the target color. Figure 8 shows the results of color edge detection.

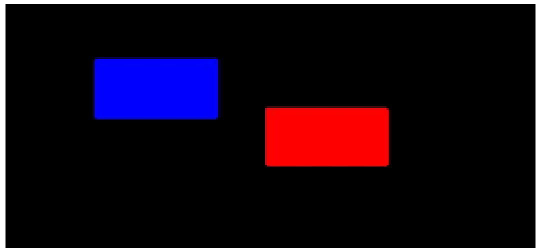


Figure 8. Color Edge Detection

4.3. Boundary Detection of the Target

After locating the position of the target colors on each of the two blocks, the image is transformed to grayscale image and the position of the color edge detected is transformed to gray scale image. The target color in the blocks is the shape of rectangles. The algorithm for boundary detection[6] is applied to deduce the boundary edges of the target. Figure 9 shows the boundary edges detected.

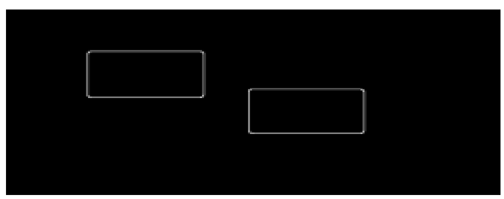


Figure 9. Boundary Detection

4.4. Subsampling the Boundary to Unit Length

The image is subsampled and the value of gridsep is assigned to represent the number of pixels per unit length. The boundary pixels are compared and analyzed to the nearest unit length pixel values. Figure 10 shows the effect of assigning different gridsep values.

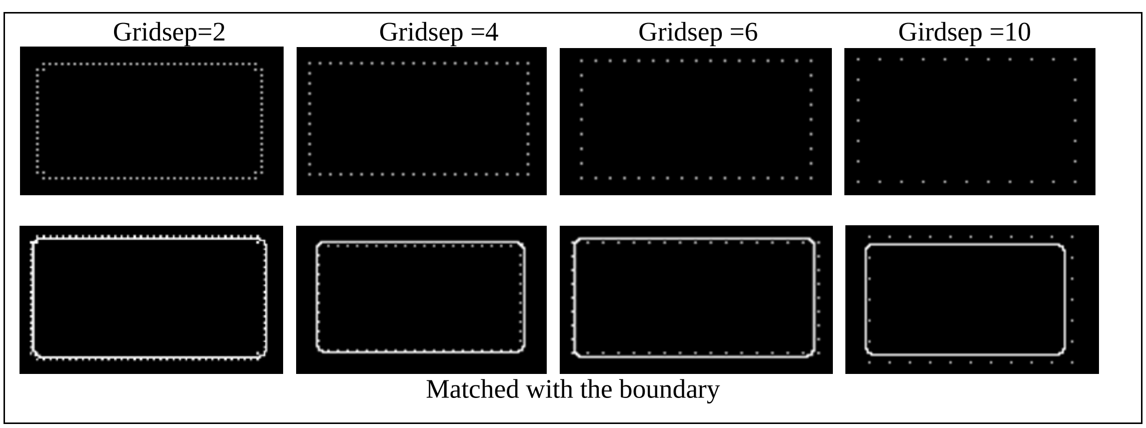
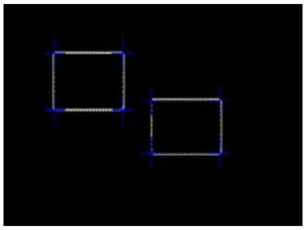


Figure 10. Subsampling with Different Gridsep Value

The result of subsampling shows the importance of assigning the gridsep value; the gridsep value represents the number of pixels per unit length. Figure 10 shows that selecting a gridsep value of 4 results the best subsampled boundary and it perfectly matches with the original target boundary with low pixel uncertainties. While further reducing the gridsep value to 2 the subsampled boundary matches more perfectly but the corner of the boundary is destroyed. Next, when the gridsep value is increased, the corners of the target boundaries are maintained, but the subsampled boundary does not match with the original boundary of the target shape.

4.5. Locating Corner of the Target

To locate the corners of the boundary, chain rule[6] is applied to the subsampled boundary. Chain code is used to represent a boundary by a connected sequence of the straight-line segments of specified length and direction. A 4-directional chain code was used in this simulation likewise an 8-directional can also be used. With the chain code generated from the subsampled boundary, the change in direction at 90 degrees is detected. With above method the corner of the target boundaries is detected, Figure 11 shows the detected corners of the target boundaries.



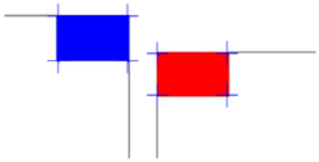


Figure 11. Locating the Corners of the Target

4.6. Selection of the Node Points to be Assembled Together

The acquisition process is done in a plane view of the target face of the block so that the properties of the target (the rectangle) can be used to identify the node points to be assembled. Figure 12 shows the node points to be identified in the given assembling blocks with its target shapes.

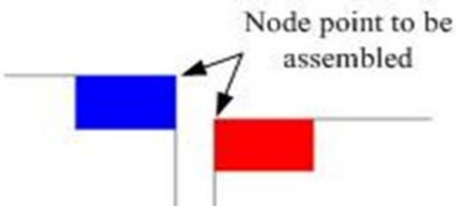


Figure 12 Nodes points to be identified

The target rectangle has two of its length larger than two of its width, this property will be used to deduce the node points required for each block. Firstly applying the chain code in the last section to deduce the corner points of the target, the first corner point is identified as the first boundary point from the northeast corner of the image, if there is several boundary points then it considers the point which lies in the lowest y-axis and is the first point from the northeast corner of the image. This process is done separately for the two assembling blocks, and each block is separated by recognizing its target color. Figure 13 shows three possible positions of blocks which can appear in the image if it is captured from the plane view of the target face, point P1 shows the first deduced corner and then P2, P3 and P4, second, third and fourth respectively. The Euclidean distance between the corner points is calculated. The distance between P1 and P2 is d12, between P2 and P3 is d23, between P3 and P4 is d34 and between P4 and P1 is d41.

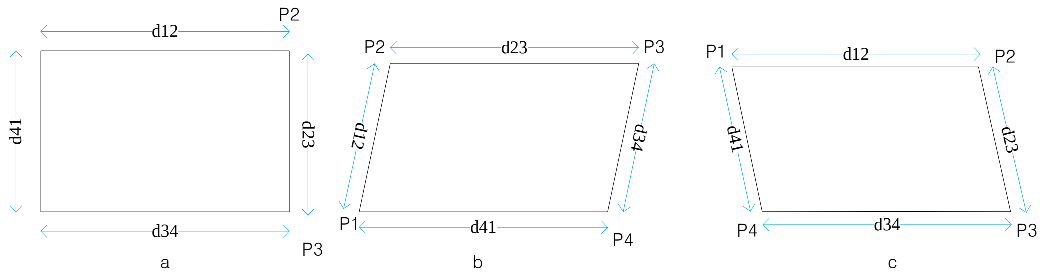


Figure 13. Possible Position of the Rectangle in the Captured Image

For each of the blocks, a rule is assigned to deduce the required node points. The Euclidean distance between the corner points is used to deduce the required node points. For the first block with blue color target, Figure 14 a shows the rule and for the second block Figure 14 b shows the rule: Appling the rules, the node points required were deduced. Figure 15 shows the deduced node points.

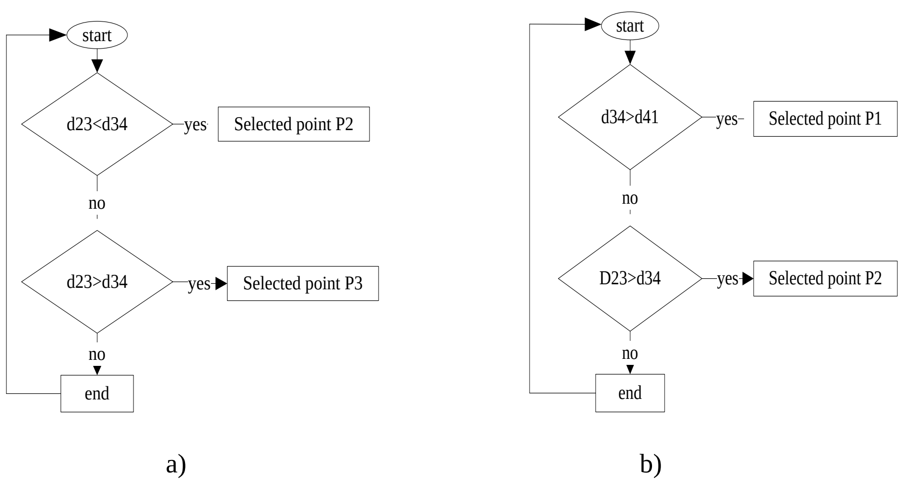


Figure 14. Rules for Identifying the Node Points, a) Rule for First Block with Blue Color Target, b) Rule for Second Block with Red Color Target

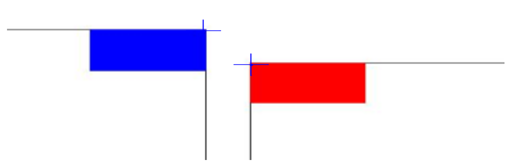


Figure 15. Image with Identified Ship Block Nodes

4.7. Deducing the Direction of Positional Declination

The x and y direction pixel difference between the identified nodes is analyzed to deduce the direction of movement to correct the positional declination. First the y direction pixel difference is reduced by directing the right positional movement direction, and then the X direction pixel difference is considered. The positional declination is achieved through the process as discussed before.

5. Conclusion

A real time monitoring system designed to monitor the assembling process of the ship blocks accounts for a profitable ship production. A high level of precision is needed in the ship production industry, previous sensor technology lack the level of precision, while combining sensor technology with image based method it turns to increase the precision for measuring distance between the target ship blocks. Furthermore image based application is used to correct the positional declination to get the correct position of the ship blocks which reduces the level of manual adjustments.

Acknowledgements

The work was supported by Priority Research Centers program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2009-0093828) and MKEC (The Ministry of Knowledge Economy), Korea, under the ITRC (Information Technology Research Center) supported program supervised by the NIPA, National IT Industry Promotion Agency (NIPA-2012-H0301-12-2005).

References

[1] Y. Okumoto, "Facters on Dimensional Inaccuracy of steel block Assembly", Proceedings of the Twelfth International Offshow and Polar Engineers Conference, Kitakyushu, Japan, **(2002)** May 26-31.
[2] S. Lee, S. Eun and J. J. Jung, "Appication of Sensor Technology for the Efficient Positioning and Assembling of Ship Blocks", International Jourrnal of Navel Art, vol. 2, no. 3 **(2010)**, pp. 171-176.
[3] K. Han, "A study on enhancing precision for mid and small size block assembly", Final Report of Regional Industry Promotion & Development Research, Ministry of Commerce, Industry and Energy, Seoul, **(2006)**.
[4] J. Hightower and G. Borriello, "A Survey and Taxonomy of Location Systems for Ubiquitous Computing", Technical Report UWCSE- 01-08-03, University of Washington, **(2001)**.
[5] S. Lee, "Sensor-based Remote Monitoring for Ship Blocks", Journal of korea Content, vol. 9, no. 1, **(2009)**, pp. 2926-2931.
[6] R. C. Gonzalez, R. E. Woods and S. L. Eddins, "Digital Image Processing", Peason Prentice, New Jersy **(2004)**.
[7] L. R. Storch. and R. J. Gribskov, "Accuracy control for U.S. shipyards", Journal of Ship Production, vol. 1, no. 1, **(1985)**, pp. 64-77.
[8] M. Manninen and J. Jaatinen, "Productive Method and System to control Dimensional Uncertainties at Final Assembling Stages in Ship Production", The Society of Navel Architects and Marine Engineers,**(1992)**.

Authors

R. Sharma

September 2011 ~ present MS Student, Dept. of Electronics Engineering, Mokpo National University, South Korea.

November 2007 Received Bachelor of Engineering Technology from University of the South Pacific, Fiji

<Research Area> Image Processing, Pattern Recognition, Wireless Communication, M2M and Robotics application.

S. R-Lee

September 1997 ~ present Professor at Mokpo National University, Department of Information & Electronics Engineering.

August 1996 ~ Received Ph.D. form Korea Advanced Institute of Science and Technology.

February 1990 ~ Received Master of Engineering from Korea Advanced Institute of Science and Technology.

<Research Area> USN / Telematics applications, Embedded systems, Digital communication systems, Mobile and Satellite communication systems.