Visualization of Simultaneous Localization and Mapping using SVG

Non Destructive Observations and Visualization of Robotic System

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***Abstract*—Robotic system often use simultaneous localization and mapping method in their operations. Most of the calculation stored as a nested array with multiple level and dimension. SLAM data contains robot movement, object detection and relation between them. This system visualize SLAM data into a map containing robot historical position, object position and relation between object and robot that show detections line from each robot position. The visualized so human eye can understand it. This paper describes the process of movement and detection data composition and conversion to prepare the information required to build a map. The map composed by plotting every movements and detections into polar coordinate area. The map stored into a database for flexible future usage. Commonly used web based interface chosen to display the map via web browser. The map generated by server side scripts that transform polar data into full map.**

Keywords-component; SLAM, Robotic, SVG, Visualization.

I. INTRODUCTION

Simultaneous localization and mapping (SLAM) first announced on IEEE Robotics and Automation Conference in 1986. SLAM problem asks possibilities of generating map and simultaneously determining locations of a mobile robot dropped at unknown location in an unknown environment [3]. The SLAM problem is actually solved using several algorithms developed, but still there are many area of development available.

The robot taking observations of several unknown objects in SLAM [3]. The object detections data contain its relative position from the robot. Along with the robot movement, the object relative position changes. Every detections data processed to estimate the exact position of the objects.

Reference [2] show that the movement of the robot can can be represented by a vector with the angle and distance of the position of the robot at one time relatively from the previous position and the next position relatively from the current position. The object detection can also represented as a vector that store the distance and angle of the object position relatively from the current robot position. The essential SLAM problem is displayed in Fig. 1.

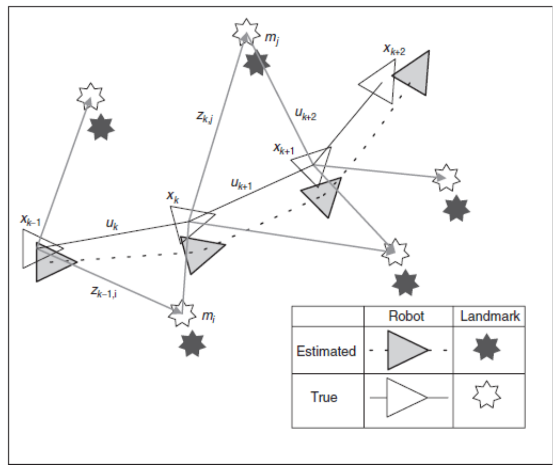

Figure 1. The essential SLAM problem.

SLAM research in the past decade focusing on process efficiency while maintaining precision [5]. In order to reduce computation complexity and memory a large scale environment map can be split into several smaller maps [4]. SLAM observation resulting movements and detections data processed and stored into local map containing every object relative position and the robot historical position. All the local maps later can be composed into single large scale global map.

This research observes existing SLAM system using non-destructive method in order to visualize the SLAM system to be understood by human eye. The system got it's input from the slam movement and detections data and process it to generate a map. The system checks for data consistency, once there data inconsistency found, the system then generate a new map separated from the previous one. Various data source can be used such as SLAM databases, log file, or using various interfacing method with the SLAM system.

II. DATA PREPARATION

This research capable of building maps from many interface method. Different SLAM system creates different data structure. To ease the process, this system prepares the input data using several data composition method:

- Data extraction from the SLAM systems, can be file reading, database query or other interfacing method.
- Unit conversion from the SLAM system only if required to store the data in metric system.
- Data cleaning to ignore system message or redundancy record so only the required data stored. Data cleaning also held to skip unused column from the record.
- Data consistency checked in order to determine is the current record related with the previous record in order to store the data as the same map data or a new map data.

This research use simulation to test processing SLAM data. Simulation data prepared using random object placement in two dimension area. The observation area and the robot movement plans displayed in Fig. 2.

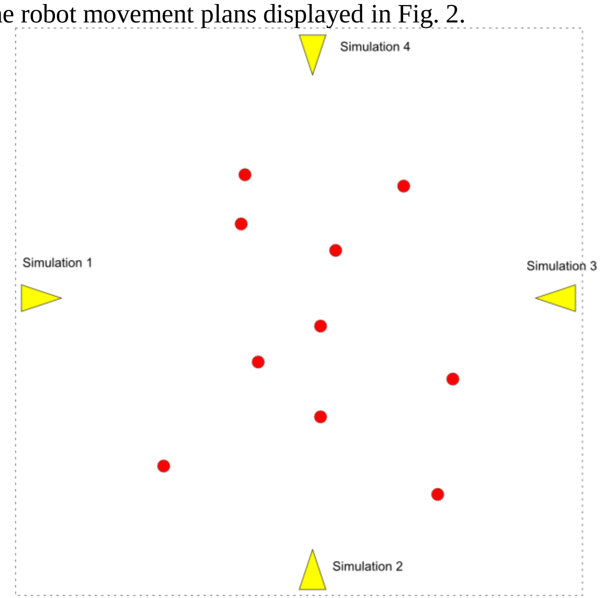

Figure 2. Simulation map

Fig. 2 display several object randomly placed in the map as red square. Simulation held four times with different robot starting point displayed as yellow triangle in the map. The movement and detection data measured and stored into a database. The data stored then processed using data preparation method and stored separately as movement data and detection data for the next process.

III. Movements and Detections Recapitulation

The next process is recapitulation. The movement and detection data processed separately. The movement data recapitulation resulting historical robot position for each map while the detection data recapitulation resulting estimated object position for each map. Robot and object positions are represented in polar coordinate system.

A. Movements Recapitulation

Movement recapitulation process can be done using simple vector addition concept that the final robot position is the summary of the movement vector and the previous position vector [2]. The robot orientation changes in every movement. The final orientation of the robot is the summary of every rotation movement [2]. For $\vec{A}_n$ is the position of robot A at step n with two vector component l_n and α_n while βn is the orientation of robot A movement recapitulation process described in (1), (2) and (3).

$$l_n = \sqrt{\left(\sum_{x=1}^{x=n} l_x \sin\theta_x\right)^2 + \left(\sum_{x=1}^{x=n} l_x \cos\theta_x\right)^2} \qquad (1)$$

$$\theta_n = \tan^{-1}\frac{\left(\sum_{x=1}^{x=n} l_x \sin\theta_x\right)}{\left(\sum_{x=1}^{x=n} l_x \cos\theta_x\right)} \qquad (2)$$

$$\beta_n = \sum_{x=1}^{x=n} \theta_x \qquad (3)$$

Tangent operations cycle resulting the same value for every 1800 that arctangent operations might resulting two different angle. In order to get the correct angle, opposite and adjacent analysis required.

B. Detections Recapitulation

Detections recapitulations resulting object estimated position. Using vector concept the position of the object are the resultant vector of robot position and the detection vector. The vector concept of object detection is displayed in Fig. 3 below.

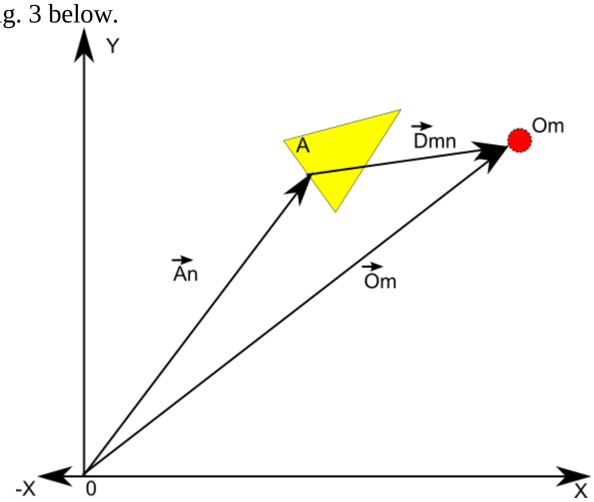

Figure 3. Object detection resultant vector

For $\vec{A}_n$ is the position of robot A at step n, $\vec{D}_{mn}$ is the detection vector of object m at step n with component vector l_{mn} and α_{mn} , $\vec{O}_m$ is the estimated position of object m with component vector l_m and α_m object recapitulation process described in (4) and (5).

$$l_m = \sqrt{(l_n \cos\alpha_n + l_{mn}\cos(\beta_n + \alpha_{mn}))^2 + (l_n \sin\alpha_n + l_{mn}\sin(\beta_n + \alpha_{mn}))^2} \quad (4)$$

$$\alpha_m = \tan^{-1}\frac{[l_n \sin\alpha_n + l_{mn}\sin(\beta_n + \alpha_{mn})]}{[l_n \cos\alpha_n + l_{mn}\cos(\beta_n + \alpha_{mn})]} \quad (5)$$

Object detections in SLAM system stored as relative value from the robot position including the orientation of the robot. To get the real vector, the detection angle required to be added with the robot orientation. As the movement data recapitulation, opposite and adjacent analysis required in detection data recapitulation.

IV. MAP GENERATION

The map generated by plotting every movement historical data and every object estimated position into drawing area. The map generations consist of two steps that are data composition and map plotting.

A. Map Data Composition

Before plotting into drawing area, the map data need to be composed from the previously explained recapitulation process. The data composition's main goal is to compose a standard form of array variables containing every movement and detection information required to generate the map. For array A containing movement data and array O containing object data, array X with map data described in (4).

$$X = [A\,O] \quad (4)$$

Array of movement data contain historical position data from the first step to the last step notated as A_n described in (5) while array A_n containing robot position at step n described in (6)

$$A = [A_1\,A_2\,...\,A_n] \quad (5)$$

$$A_n = [l_n\,\alpha_n\,\beta_n] \quad (6)$$

Array of object data contain every estimated object m described in (7) while O_m containing object's estimated position and array of detection history described in (8).

$$O = [O_1\,O_2\,...\,O_m] \quad (7)$$

$$O_m = [l_m\,\alpha_m\,D_m] \quad (8)$$

Array D_m contain every detection of object m at step n described in (9). Array D_{mn} contains relative detected object position described in (10).

$$D_m = [D_{m1}\,D_{m2}\,...\,D_{mn}] \quad (9)$$

$$D_{mn} = [l_{mn}\,\alpha_{mn}] \quad (10)$$

B. Map Plotting

The plotting progress transforms array data from the previous section into two different map that is simulation map and local map. Both map display robot movement and mark every historical position of the robot. The simulation map display object detections in every step while the local map displays the estimated object location.

Map plotting process held using SVG that has capability to display vector graphic shapes, images and texts [1]. SVG use vertically flipped Cartesian coordinate system. Vector shapes in SVG formed inside XML tags with its attribute and variables. Robot movement represented as vector path while objects positions represented using circle shapes and the robot position represented using triangle shapes. SVG script generated from first simulation resulting simulation map displayed in Fig. 4 below.

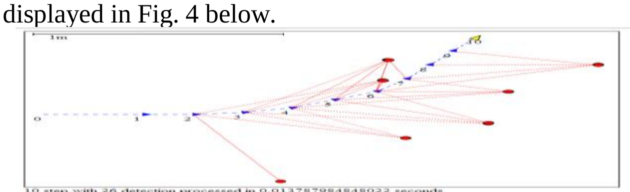

Figure 4. Simulation map from first data

Fig. 4 above display the robot movement as blue dashed line connecting blue triangle that represent robot historical position. The red circle display object position when detected by certain position connected with red dashed line. The local map also generated that display the estimated object position displayed in Fig. 5.

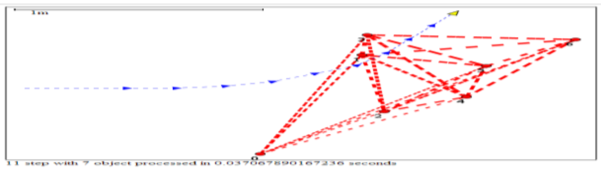

Figure 5. Local map from first data

Fig. 5 above also displays red dashed line to represent relation between objects. The relation line displayed to illustrate spring network analogy between objects. The rest of the map from second to fourth simulation displayed in Fig. 6, 7, and 8.

V. CONCLUSION

Visualization can be made to SLAM system using simple few steps. Data composition process required to prepare data into standard form to be visualized. Robot movement and object detection recapitulation process can be done using simple vector resultant concept by adding one vector into another.

ACKNOWLEDGMENT

The researcher would like to thank W3 group for proposing such a simple yet powerful vector graphic tools capable to visualize every aspect of a vector.

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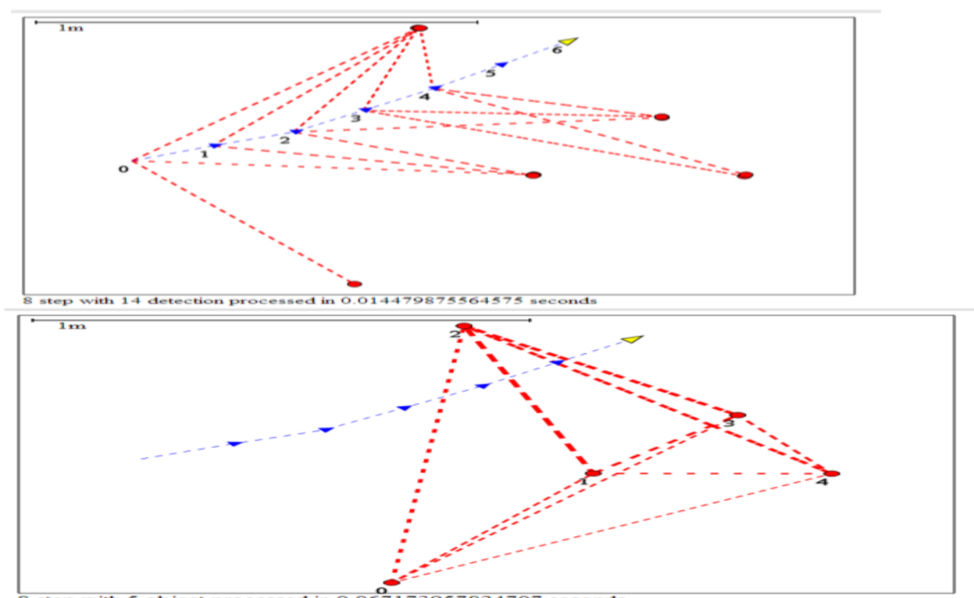

Figure 6. Simulation map and local map from second data

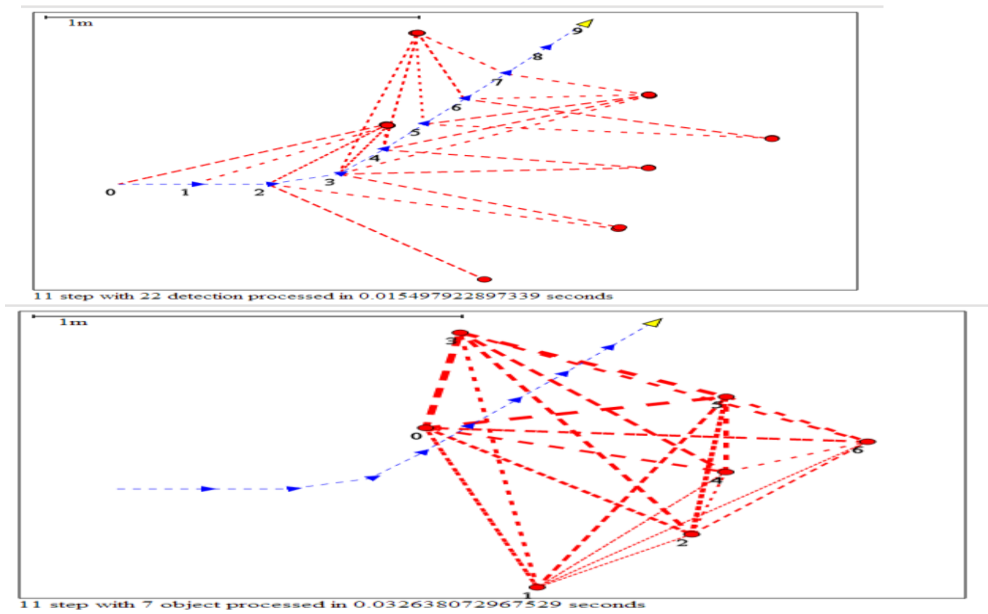

Figure 7. Simulation map and local map from third data

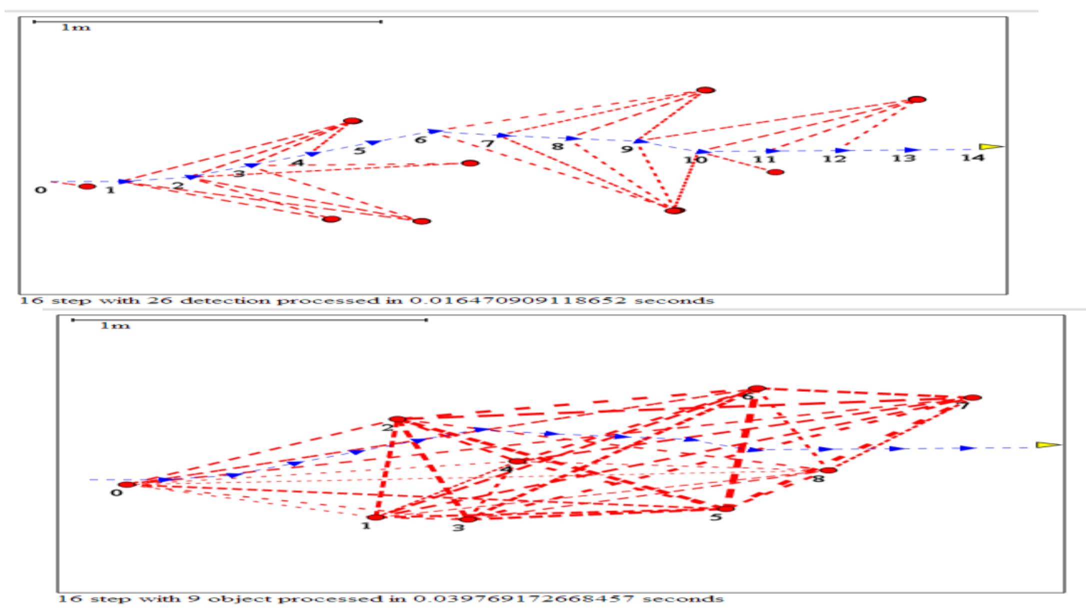

Figure 8. Simulation map and local map from fourth data