# Convolutional Neural Network using Collision Grid Map based on probability scheme for collision prediction.

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## 1. Introduction

There are many studies [1], [2] in which robots feed and monitor cattle in livestock environment. When mobile robot feeds the cattle, there is a problem with cow sticking their head out of the fence to feed them and colliding with the robot.

Recently, it was proposed Convolutional Neural Network(CNN) [3] based on image data for object classification. In proposed method [3], Neural network learns the feature of image data using gradient descent for optimizing loss function.

It has proposed in [4] has proposed that 3d point cloud data is applied to Convolutional Neural Network. Voxnet [4] modelled the occupancy grid map of three types of binary data using for 3d point cloud. VoxNet network learns the occupancy grid map to object classification.

In this paper, Collision Grid Map(CGM) is proposed using 3d point cloud data to predict the collision between the cattle and the mobile robot in barn environment. The Collision Grid Map is composed of 2-channel. First channel is constructed by location data in x-y plane. Second channel is composed of depth data about z-direction. the point cloud data is measured by situation and created the Collision Grid Map. Then, the generated Collision Grid Map is applied to the Convolutional Neural Network to predict the collision of livestock.

## 2. Collision Grid Map

There is invariant of permutation problem that 3d point cloud data is applied to Convolutional Neural Network. The proposed method [4] modelled voxel of the binary occupancy grid, density grid, hit grid. Then network is learned by voxel to solve invariant of permutation problem. The method is proposed that Collision Grid Map scheme is based on probability to solve invariant of permutation problem and predict the collision between the robot and the cattle.

Equation (1) shows measurement data **s** and grid map **M.** Measured data is x, y and z data of the sensor coordinate system. Grid map **M** consists of two channels.

$$\mathbf{s} = \{s_i\} = \{x_i, y_i, z_i\},\ \mathbf{M} = \{m_{1,i}, m_{2,i}\} \tag{1}$$

The posterior of Collision Grid Map is shown as equation (2). In order to calculate the posterior efficiently, log odds notation can be defined.

$$p(m|\mathbf{s}) = \prod_i p(m_i|\mathbf{s}) \tag{2}$$

log odds notation can be calculated using present point cloud data and previous point cloud data. when initial grid map is free state, initial Collision Grid Map can be omitted.

The first channel of the Collision Grid Map uses the decretization function G to grid the x and y data in the point cloud. When decretization data correspond to grid cell, grid cell values are added up in counts one by one.

The second channel is consisted of the average of depth z data. Grid cell has on depth value that occurred to collision situation and non-collision situation.

## 3. Experimental Results

3d point cloud data is measured in barn environment using D435 from intel as shown Fig.1. D435 has maximum resolution 1920 x 1080 and maximum frame rate 30 FPS. It can be measured up to 10 meters. The data in the case of non-collision situation, when there is fence only, has been measured 2,000 data. Similarly, the data in the case of collision situation, when cow sticks their head out of the fence, has been measured 2,000 data. The data is divided into 1,800 training data and 200 test data each.

Fig.1 Intel real sense depth camera D435

In order to generate Collision Grid Map, cell resolution is set to 0.01m and the map size to be 150 x 100. Based on the sensor coordinate, x, y with the width of 1.5m and the length of 1.0m is used, and depth data is used up to 2m. Fig.1 and Fig.2 show the results of the Collision Grid Map. Fig.1 is the collision situation, the left side corresponds to the first channel of the collision Grid Map, and the right side corresponds to the second channel. In contrast, Fig.2 is non-collision situation with a fence only, and the figure on the left corresponds to first channel and the figure on the right corresponds to second channel.

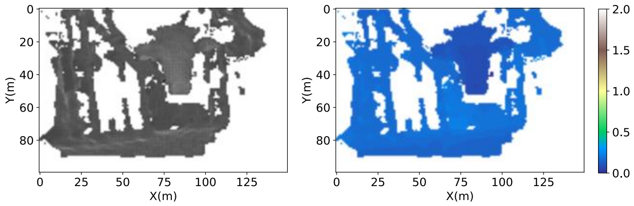


Fig.1 Result of the Collision Grid Map in the collision situation.

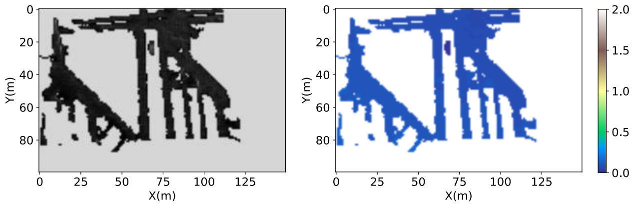


Fig.2 Result of the Collision Grid Map in the non-collision situation.

Convolutional Neural Network is set by the convolutional layer with the first layer and the size was 3x3 with the activation function using relu function. The second layer is consisted of a pooling layer using max function in 2x2 size. third layer was set as the same with the first convolutional layer. Finally, 1024 neurons are set up with a fully connected layer. Adam optimizer [5] is used for optimization.

Table 1. Accuracy result of CNN using CGM

| Method | Accuracy (%) |
| --- | --- |
| CNN using CGM | 90.0 |

Learned network is tested by 200 test data set which is measured. The accuracy results are 90.0%.

## 4. Conclusion

In this study, Collision Grid Map scheme is proposed from point cloud data to predict collision between the robot and the cattle. The results of the Convolutional Neural Network algorithm using Collision Grid Map are shown that Collision Grid Map can be obtained robust accuracy in barn environment.

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## References

[1] T. M. Banhazi, L. Babinszky, V. Halas, and M. Tscharke, “Precision livestock farming: Precision feeding technologies and sustainable livestock production,” *Int. J. Agric. Biol. Eng.*, 2012.

[2] R. J. Lehmann, R. Reiche, and G. Schiefer, “Future internet and the agri-food sector: State-of-the-art in literature and research,” Comput. Electron. Agric., vol. 89, pp. 158–174, 2012.

[3] Y. LeCun, L. Bottou, Y. Bengio, and P. Haffner, “Gradient-based learning applied to document recognition,” Proc. IEEE, vol. 86, no. 11, pp. 2278–2324, 1998.

[4] D. Maturana and S. Scherer, “Voxnet: A 3d convolutional neural network for real-time object recognition,” in 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2015, pp. 922–928.

[5] D. P. Kingma and J. Ba, “Adam: A method for stochastic optimization,” arXiv Prepr. arXiv1412.6980,2014.