Multi-Viewpoint Object Recognition

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Abstract— **Object recognition capability is a essential condition for giving autonomy to mobiles robots in human made environment. However, achieving this goal by means of visually representing objects is a hard task ?? and using all possible sources of information is a must. Here we present a procedure to incorporate the notion of continuity and overcome ambiguous points of view. By observing objects from different perspectives binded with a Markovian modeling of the stochastic processes of recognizing each of the objects viewpoint, the algorithm copes with a sparse database, blurred images from motion and object spatial symmetry, to recognize and estimate objects 6-dof pose. A multi-modal Kalman based tracking was also implemented in order to recognize multiple objects simultaneously. The approach was tested in a mobile platform and the comparison between the single viewed and the proposed recognition gave promising results.**

I. INTRODUCTION

The vast majority of the literature focus on single image object visual recognition for helping robots in tasks such as semantic navigation **??**, pose estimation for grasping **??** and environmental search **??**. Typically, a set of features is extracted from a segmented object candidate and, subsequently, compared to a database of priori known objects. Extensive work have been done in order to increase efficiency in each one of the sub-processing steps. Among them : segmentations methods using range cameras, features that describe color and texture **??**, geometry **??**, contours **??**, besides classifiers and matching techniques. Alternatively, a deep neural architecture **??** can perform a direct object visual classification after a delicate training phase. However, the classic recognition pipeline seems to be more natural and simple to be implemented with a straight-forward training, still having reasonable results.

Nevertheless, ambiguous viewpoints easily trick visual descriptors reducing its recognition capability. Observing objects sequentially from distinctive points of view seems to be a natural way to deal with the problem. A solution inspired by human behavior for learning new unseen objects has been proposed by **??**, using key-frames and the rate of matching features with past frames, to overcome ambiguity in face recognition task. More work have been done to model objects different viewpoints perspectives summarized by Roy and al. **??**.

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II. PROPOSED METHOD

We present a viewpoint multiple object recognition for indoor environments.

A. Object Segmentation

The segmentation step concerns on differentiating the object from the background of raw image. Stereoscopic and infra-red cameras helped the treatment adding a new dimension to images and allowing segmentation geometrically. In our case, objects are consider as cluster of points right above the ground plan. The segmentation algorithm proposed by **??** consists, therefore, in using the plan equation, acquired from an initial calibration phase, and its normal to find orthogonal walls and subtract all these background elements; and a euclidean clustering algorithm to group close points into clusters. Despite simplifying the feature extraction process, the given definition constrains the object segmentation capability.

B. Feature

Among all kind of image features, the Viewpoint Feature Histogram captures the object geometry by estimating the angular transformation between the normal of each of the object's point and the standpoint from where it has been viewed. The interest of using such a feature is to explore the ambiguity created from objects spatial symmetry.

C. Aspect-Graph

In order to represent objects in the 3 dimensional space, an aspect graph representation merges viewpoint appearance and the necessary movement to transit between them.

D. Multi-object Tracking

E. Viewpoint Recognition

III. EXPERIMENTS

The proposed recognition system was deployed in a differential mobile robot, Wifibot V2, embedded with a RGB-D camera, Asus Xtion Pro Live. The algorithm architecture were implemented over ROS using PCL and OpenNi2 libraries. In the interest of validating the approach, the robot was initially taught objects aspects graphs and two sets of experiments were proposed to analyze the efficiency of the algorithm in real scenarios.

A. Object Database

First, twenty objects varying in size and form were selected to compose the robot knowledge database. The objects aspect graphs were composed by VFH features from eight equally distant viewpoints acquired from positioning the robot around the to be learn object 1.5 meters away. Each of the feature was labeled

B. Performance testing

The first experiment consist in a performance comparison between the single and multi image recognition techniques. In other words, this comparison attest whether the architecture is interesting or not, since having same performance by the cost of adding a complex post-processing and tracking modules is not interesting.

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TABLE I
AN EXAMPLE OF A TABLE

One	Two
Three	Four

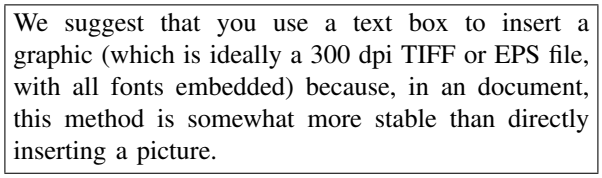

Fig. 1. Inductance of oscillation winding on amorphous magnetic core versus DC bias magnetic field

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V. CONCLUSIONS

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

APPENDIX

Appendixes should appear before the acknowledgment.

ACKNOWLEDGMENT

The preferred spelling of the word acknowledgment in America is without an e after the g. Avoid the stilted expression, One of us (R. B. G.) thanks . . . Instead, try R. B. G. thanks. Put sponsor acknowledgments in the unnumbered footnote on the first page.

References are important to the reader; therefore, each citation must be complete and correct. If at all possible, references should be commonly available publications.

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