AN INTELLIGENT SYSTEM SEARCH FOR INDOOR COLOR RECOGNITION: A COMPARISON

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Abstract: This work addresses a map-based method for the localization of mobile robots (wheeled or legged) in indoor environments, using monocular vision. This method is comprised of four stages: image acquisition, image feature extraction, image and model feature matching and camera pose computation. A special attention is given to the matching phase. In particular we research the advantage of including a retinex pre-processing stage in neural networkthe color classification schemes. Results presented suggests that this is correct.

Keywords: Image Processing Retinex Neural Networks

1. Introduction

Autonomous guided vehicles are increasingly common these days and will be more in a near future. Effectively their use has been extended to domestic applications, such as cleaning robots or for assistance of disabled persons, but also in public buildings, such as museums, serving as visitor guides. These applications all have in common the fact that they are indoor environments. And many more applications can be envisaged. In these environments, the robot must be autonomous, being able to fulfill a navigational task, which involves reaching a goal with no human intervention, while at the same time avoiding obstacles and people..

There are mainly two types of AGV's, free-path or free-ranging (1). Fixed path guidance refers to a physical guide path (e.g., wire, tape, paint) on the floor that is used for guidance, and free-ranging guidance has no physical guide path, thus it is easier to change the vehicle's path (in software), but absolute position estimates (optical or laser guided) are needed to correct dead-reckoning error (2)

A human do not use neither a path way on the floor for navigation (eventually for orientation), neither requires a laser to sense the area in front. Rather than that it uses vision, from which he can extract the relevant information for the short path in front, and memory for getting orientation and reference points.

We believe that a robot can work with this information only.

To be autonomous, the robot must be able to compute and update position and orientation relative to a fixed global frame.

This work addresses a map-based method for the localization of mobile robots (wheeled or legged) in indoor environments, using monocular vision. This method is comprised of four stages: image acquisition, image feature extraction, image and model feature matching and camera pose computation. A special attention is given to the matching phase.

Results are presented for a real indoor environment, suggesting being adequate towards the envisaged applications

2. Previous work

The problem of indoor localization has been addressed by a variety of techniques. Among them map based approaches techniques are often used. Typically there are three main types of map representations: topological maps, grid maps and geometric models. The environment model can either be pre-stored or built online simultaneously.

When performing map-based localization, an usual approach is to match the local representation of the environment, with the model map.

The matching phase is a critical step, since it involves determining the correct correspondence between image features and model features. To address the problem of map-based robot localization using visual sensors, Kosaka et al (3) proposed a method where robot orientation and position were updated from initial conditions, according with navigational commands. The new robot pose is used to project model features on the image plane and compare them with the actual image being viewed. Uncertainty on the new robot position and orientation is propagated to predict uncertainty zones in the image, where a search for corresponding features is required. This method requires a high sampling rate and not every image acquisition may provide enough information to accurately update the robot pose. Talluri et al (2), introduced the notion of Edge Visibility Regions. These are used to restrict the matching process to a small subset of features in the global model. However it only focuses on horizontal features, representing rooftop edges.

In this work a map-based localization method using monocular vision is researched. The focus will be on the critical matching phase, between image and model features. The approach researched is based on color correspondence. The environment model is constructed offline and pre-stored. The map is of the geometric type and contains the main parts of the environment, which are not supposed to move, such as wall and door edges.

3. Indoor Map Building

Indoor environments considered in this work are man-made and semi-structured. These are typically delimited by flat surfaces, such as walls, ground and ceiling. The intersections between these flat surfaces tend to be straight lines, the edges.

Figure 1 *Interior scene with light gradient*

The built model contains the main parts of the environment that are not supposed to move, such as walls and door edges, and is of the geometric type, that is, it contains the lengths of each edge and its position relative to a global fixed frame.

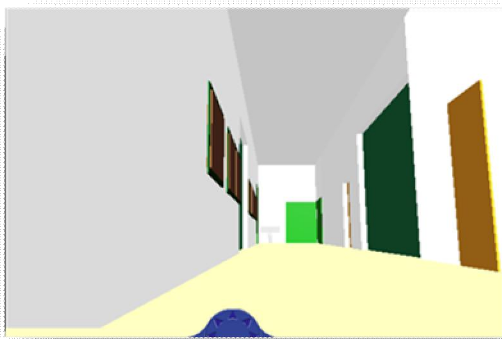


Figure 2 *Interior scene model in VRML*

4. Color Models

The basic system is color is the RGB (red-Green and Blue), used by the majority of the cameras. A more suitable system for computer processing is the HSV (Hue –saturation-brightness). The later correspond to an axe rotation from the RGB, making the lightness value to be defined by the extreme points (black and white).

In computer vision segmentation refers to the process of partitioning a digital image into multiple segments (sets of pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze (5). Image segmentation is typically used to locate objects and boundaries (lines, curves, etc) in images.

More precisely image segmentation is the process of assigning a label to every pixel in an image, such that pixels with the same label share certain visual characteristics.

In the particular case of this work, image segmentation refers to the process of identifying components in the image. And one logical approach is to search for color areas, which in interior environments can be many times linked with a particular type of objects (e.g. doors are coherent in color).

This approach seems logical; the implementation is a little more difficult, as the illumination gradients make the colors vary, and in particular the triplet of values. This is not evident all the times due to the 'quality' of the human visual system. Color constancy mechanisms compensate this characteristic. Unfortunately these are not reproducible in computer vision. So we look for a method to correct the brightness that allows that similar color appears similar in the image.

4.1. Retinex model of vision

In the early 70's Land and McCann (5), (6) introduced the retinex model for the computation of lightness. Since then, variants have been presented mainly to improve the computational efficiency of the model. Among them, Funt et al (7) (8) have presented a MatLab implementation which is used through this paper.

Retinex calculations aim to calculate the sensory response of lightness. According to the authors, "For testing the retinex model it is crucial that the data be calibrated in the sense that the image digit values must be a logarithmic function of scene radiance and they must be represented with sufficient precision". This is a problem, as we use, and intend to use standard cameras. Nevertheless we are investigating the ability to homo

Retinex algorithms present this characteristic, and thus Funt et al algorithm was tested, presenting a poor performance. However during the tests performed it seems to perform well in some images where the color didn't have much variation.

A small variation from the strategy proposed gives much better results. Effectively, retinex algorithm is being using for reassigning of the brightness component of the image. We split the image in the HSV sub-matrices, apply the method to the v-image (as monochromatic), and reconstruct the image with the H, S and, corrected V.

4.2. Artificial Neural Networks

Artificial Neural Networks (ANN) are structures that mimic the human brain and who have the capability to learn. They have been used for edge detection (10)and edge detection arbitration, among other applications. (10) (11)

Among the several approaches that could be used in implementing this process, an artificial neural network seems to be particularly suited to this job.

Effectively, artificial neural networks can handle incomplete or corrupted sets of data thus they can be applied to the recognition of images, can be used to infer the position of missing edges or misplaced edges based on the knowledge applied by the different edge detection techniques described or color identification. To this purpose a multi-layer back-propagation neural networks are being used. These types of networks are capable of reproducing an input/output relation, learned from a repetitive exposition to a set of examples. They also have an inherently parallel structure allowing for a parallel implementation.

4.3. Results

Examples of the execution of the algorithm are presents in the following pictures. **Figure 3** until 8 are from interior scenes, corridors at Technical University of Lisbon, under normal light. Images were taken with a digital camera, Olympus 750UZ, with 4 Mpixels, and resized. They are originally jpeg images from the camera. No further processing was done.

The processed images present more objects, darker areas are visible, without 'burn' the more brilliant areas.

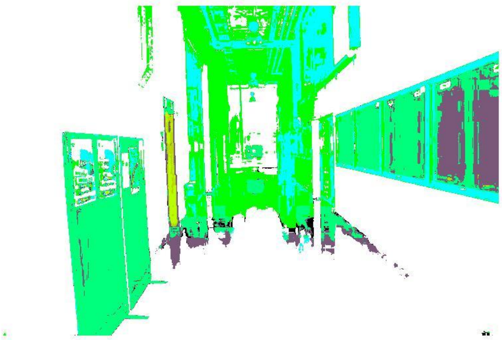
Figure 3 *Interior Scene - Original*

Figure 4 *Interior Scene – Processed*

Figure 5 *Interior Scene - Original*

Figure 6 *Interior Scene - Processed*

ANN are trained with a sample of the colors. The colors are manually handpicked. The network is then applied to the original image and the Retinex processed image



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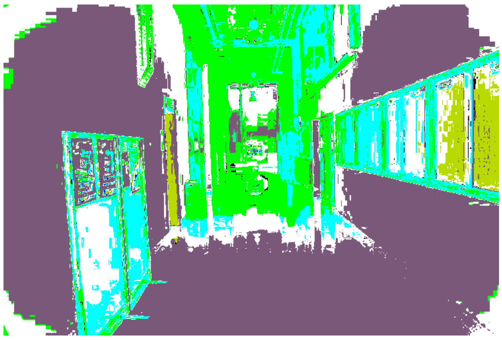

Figure 7*-Corridor after retinex (Figure4) processed by the ANN*

Figure 8- Corridor (Figure4) processed by the ANN

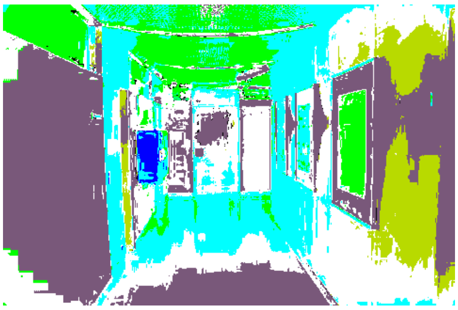

Figure 9 *Office corridor after retinex processed by ANN*

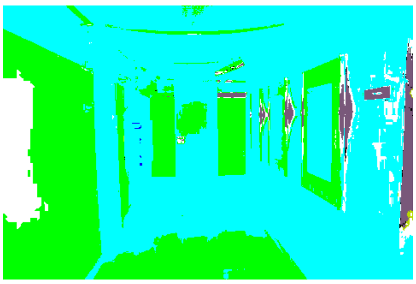

Figure 10 *Office corridor processed by ANN*

5. Conclusions and Work under Development

This work presented studies towards a collaborative frame-work for the localization and cooperation of mobile robots in indoor environments. We studied one method for color identification for a segmentation of interior scenes. The integration of the system into a robust color identification algorithm, e.g. Neural Networks, was studied. It can be seen from the examples that the preprocessing with the retines algorithm will increase the ann function. Results are very promising.

6. Acknowledgments

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7. Bibliography

[1]. WikiMehda . *http: //www.wikimheda.org /wiki/AGV.* [Online] [Cited: 09 21, 2010.] http://www.wikimheda.org/wiki/AGV.

[2]. Industrial Trucks. *About the MHE Taxonomy.* [Online] [Cited: 09 21, 2010.] http://www.ise.ncsu.edu/kay/mhetax/TransEq/IndusTr/index.htm#Light%20load%20AGV.

[3]. **Kosaka, A. and Kak, A.C.** Fast Vision-Guided Mobile Robot Navigation Using Model-Based Reasoning and Prediction of Uncertainties. *Computer Vision, Graphics and Image Processing - Image Understanding.* 1992, Vol. 56, 3, pp. 271-329.

[4]. **Talluri, R. and Aggarwal, J.K.** Mobile robot self-location using model-image feature correspondence. *IEEE Trans. Rob. Autom.* 2005, Vol. 12, 1.

[5]. **Shapiro, L.G. and Stockman, G.C.** *Computer Vision.* New Jersey : Prentice-Hall, 2001.

[6]. **McCann, Edwin Land and John.** *Method and System for Image reproduction BAsed on Significant Visual Boundaries of Original Subject. 3 533 360* 1971. US Patent.

[7]. **Edwin Land, John McCann.** Lightness and Retinex Theory. *Journal of the Optical Society ogf America.* 1971, Vol. 61, 1.

[8]. **Briean Funt, Florian Ciurea, John McCAnn.** Retinex in MatLab. *http://www.cs.sfu.ca/~colour/publications/IST-2000/retinex_mccann99.m.* [Online] [Cited: Sep 15, 2010.]

[9]. **Brian Funt, Florian Ciurea, and John McCann "," Proceedings of the IS&T/SID Eighth Color Imaging Conference: Color Science, Systems and Applications, 2000, pp 112-121.** Retinex in Matlab. *Proceedings of the IS&T/SID Eighth Color Imaging Conference: Color Science, Systems and Applications.* 2000, pp. 112-121.

[10]. *Integrating Parallel edge detection Schemes using Neural Network Arbitration.* **Ramalho, M and Curtis, KM.** s.l. : ICSPAT'93, USA, 1993.

[11]. *Edge detection using neural network arbitration;.* **Ramalho, Mário and Curtis, K.** s.l. : IEE Conf. Pub. 1995, 514 (1995),, 1995.

[12]. **Ramalho, M and Curtis, KM.** Neural Network Arbitration of Edge Maps. [book auth.] A, Jane, M and Marini, D. (Eds), Gloria. *Transputer Applications and Systems'94;.* s.l. : IOS Press, Netherlands, 1994.

[13]. **Borenstein, J., Everett, H.R. and Feng, L.** *Navigating Mobile Robots: Systems and Techniques.* s.l. : Wellesley, Mass.:AK Peters, 1996.

[14]. **Borenstein, J., Everett, H.R. and Feng, L.** *Navigating Mobile Robots: Systems and Techniques.* Wellesley, Mass : AK Peters, 1996.

[15]. **Aider, O.A., Hoppenot, P. and Colle, E.** A model-based method for indoor mobile robot localization using monocular vision and straight-line correspondences. *Robotics and Autonomous Systems.* 2005, Vol. 52, 2, pp. 229-246.

[16]. **Kim, J.S. and Kweon, I.S.** Estimating Intrinsic Parameters of Cameras using Two Arbitrary Rectangles. *Proc. 18th Int. Conf. Pattern Recognition.* 2006, Vol. 1, pp. 707-710.

[17]. **Simsarian, K.T., Olson, T.J. and Nandhakumar, N.** View invariant regions and mobile robot self-localization. *IEEE Trans. Rob. Autom.* 1996, Vol. 12, 5, pp. 810-815.

[18]. **Valente, Filipe.** *Movement and Image Prediction.* Lisbon : MSc Thesis, IST,TU Lisbon, 2009.