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G. Yermagambet[1]
[1]Suleyman Demirel University, Kaskelen, Kazakhstan

MACHINE VISION IN ROBOTIC SYSTEMS

Abstract. The article describes machine vision, its application areas and the use of machine vision view in robotics.

Robot vision refers to the capability of a robot to visually perceive the environment and use this information for execution of different tasks. Visual feedback has been used extensively for robot navigation and obstacle avoidance. In the recent years, there are also examples that include interaction with people and manipulation of objects. In this paper, we review some of the work that goes beyond of using artificial landmarks and fiducial markers for the purpose of implementing vision based control in robots. We discuss different application areas, both from the systems perspective and individual problems such as object tracking and recognition.

Keywords: machine vision, robotics.

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Аннотация. В статье описывается машинное зрение, области его применения и использование машинного зрения в робототехнике.

Под зрением робота понимается способность робота визуально воспринимать окружающую среду и использовать эту информацию для выполнения различных задач. Визуальная обратная связь широко использовалась для навигации роботов и обхода препятствий. В последние годы есть также примеры, которые включают взаимодействие с людьми и манипулирование объектами. В этой статье мы рассмотрим некоторые из работ, которые выходят за рамки использования искусственных ориентиров и фидуциальных маркеров с целью реализации контроля на основе видения в роботах. Мы обсуждаем различные области применения, как с системной точки зрения, так и с отдельными проблемами, такими как отслеживание и распознавание объектов.

Ключевые слова: машинное зрение, робототехника.

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Аңдатпа. Мақалада машиналық көру, оның қолдану салалары және робототехникадағы машиналық көруді қолдану сипатталады.

Роботтың көзқарасы - бұл роботтың қоршаған ортаны көзбен көріп, әртүрлі тапсырмаларды орындау үшін осы ақпаратты пайдалану мүмкіндігі. Көрнекі кері байланыс роботты навигация және кедергілерді болдырмау үшін кеңінен қолданылды. Соңғы жылдары адамдармен өзара әрекеттесуді және объектілерді басқаруды қамтитын мысалдар бар. Бұл мақалада біз роботтардағы көруді бақылауды жүзеге асыру үшін жасанды бағдарларды және фидуциалдық маркерлерді пайдаланудан тыс кейбір жұмыстарға назар аударамыз. Біз жүйелік тұрғыдан, сондай-ақ қадағалау және объектіні тану сияқты жеке мәселелермен әртүрлі бағдарламаларды талқылаймыз.

Түйін сөздер: машиналық көру, робототехника.

Introduction

Machine vision is the use of computer vision in industrial operations and in production. In that period of time, when computer vision is a common set of methods, allowing computers to see, the field of interest of computer vision as an engineering direction is digital input and output devices, as well as computer networks for monitoring production equipment, such as: robot manipulators or devices for extracting defective parts.

Machine vision is a subdivision of engineering. It is related to computing, optics, engineering and industrial automation. Most common machine vision applications are industrial product inspections. These include: semiconductor chips, cars, food and medicine. People who carried out work on assembly lines, looked at parts of products and made conclusions about the quality of performance. For these purposes, computer vision systems use digital and intelligent camera types, as well as software variations that can process images for similar checks. They are programmed to implementation of highly specialized tasks, such as counting objects on conveyors, reading serial numbers or searching for surface defects [1].

Machine vision helps solve complex industrial tasks reliably and consistently

A typical machine vision solution in robotic systems has several of the following components:

1. One or a number of digital or analog cameras (black and white or color) with suitable optics for obtaining images.

2. Software for making images for processing. For analog cameras, this is a digitizer of images.
3. Software tools for machine vision, which provides tools for the development of individual software applications.
4. Input and output equipment or communication channels for reports on the results obtained.
5. Smart camera: the only device in which there are all the above points.
6. Special light sources (LEDs, fluorescent and halogen types of lamps, etc.).
7. Specific software applications for image processing and detection of relevant properties.
8. A sensor for synchronizing detection parts (often optical or magnetic sensors) for capturing and processing images.
9. Drives of certain shapes that are used for sorting or dropping corrupted parts.

Using a synchronization sensor, it is possible to determine when parts, often moving along a conveyor, are in positions to be inspected. The sensor starts the camera and takes a picture of the part when it passes under the camera and is often synchronized with the light pulses. It is possible to make a clear image.

Lighting, which is used to highlight parts, is intended for highlighting features that represent interests and concealment, or minimizing the appearance of features that are not interesting (for example, shadows or reflections). For this purpose, often used LED panels of suitable size and location.

Machine vision is used in various fields of activity and is not limited to some of them:

- large industrial production;
- accelerated production of original products;
- industrial safety systems;
- control of previously manufactured objects (for example, quality control, the study of errors);
- systems of visual control and management (record keeping, bar code recognition);
- control of automated vehicles;
- quality control and food inspection.

Machine vision should be considered as a much more complex and technological area of scientific and engineering knowledge, which covers all the problems of developing practical systems: selection of lighting schemes of the scene, the choice of sensor characteristics, their number and location geometry, calibration and orientation issues, equipment selection or development for digitization and processor processing, the development of the algorithms themselves and their computer implementation - that is, the whole range of related tasks.

In addition, there is such a thing as the vision of robots. This is a narrower field of computer vision technology, namely, the part that ensures the functioning of computer vision systems under severe time constraints. For example, equipping new generation robots with mobile cameras and stereovision algorithms, many companies are working to create intelligent robots that can not only freely navigate the apartment and recognize their masters, but also perform certain tasks for remotely submitted teams.

Robotics is the traditional field of application for machine vision. Despite this, the main part of the robots for a long time was in the industry, where the sensitivities of the robots are not were redundant. Due to well-controlled conditions (low non-determinism of the environment), highly specialized types of solutions were possible, including for machine vision tasks. In addition, industrial applications allowed the use of expensive types equipment that had varieties of optical and computing systems.

Modern robotics needs solutions from a wide range of computer vision tasks. This includes:

• a set of tasks that are associated with orientation in external space (for example, the tasks of simultaneous localization and mapping);

• tasks of recognizing different objects and interpreting scenes in general;

• tasks to detect people, recognize their faces and analyze emotions.

Machine vision in robotic systems has every chance to surpass human in the next 10 years. Already, robots can see through walls and for many kilometers ahead.

Machine vision systems have fairly good prospects. The ideal machine vision system will be fully built on digital technologies, will use smart cameras and low-cost equipment that implements a set of standardized functions for image processing and recognition [2].

Object Detection, Initialisation of Tracking Initialisation has the goal to select and possibly identify a target. It is in itself hardly treated as a research topic and commonly relies on object recognition methods or constraints on tracking. As an example, most approaches of visual servoing exploit an initial constraint. Such simplifying constraints are light objects on dark background, LEDs, black and white markers, colored objects, objects with surfaces of different grey values, given correspondences, restriction to a ground plane or manually selected features. Obviously, these constraints limit applicability and do not allow recovery after loss of tracking. Another example are static tasks, where initialisation is relatively simple and uses techniques such as image subtraction or optical flow calculations. Both techniques highlight areas in the image where a motion has been detected. If a CAD-model of the target is available, an initial pose estimate can be used to project the features into the image, e.g., [3]. A classical technique of initialisation is object recognition. A common approach is to match image features in the initial image to features in a database made for single or multiple objects. The match reports either object hypotheses or hypothesis of a specific view, which are subsequently verified to report the most likely object. Thus, as a by-product of the recognition process, an estimate of the object pose may be provided. For a comparison of different feature detectors we refer to. It should be noted that initialisation differs from recognition in that one specific object has to be found and located, practically reversing the classical recognition process of identifying all objects in the scene. Impressive recognition results have been reported. Nevertheless, object recognition suffers from two common problems: (1) Methods today rely mostly on sets of features. If these features cannot be detected reliably, recognition rates decrease rapidly. The difficulty is that recognition as part of robot vision requires the ability to detect objects under varying viewing angle, significant changes in scale and illumination conditions. Although great improvements have been achieved over recent years, robotic tasks remain difficult (2). Methods are mostly designed for databases, where objects are centred. Hence a first selection of targets has been achieved by the person that took the image, while a robot would need to search and take these images first. This difficulty adds to the problem discussed above. For example, methods require good line features or a perfect segmentation. The latter methods show sensitivity to changing background or lighting (reported are objects on dark or pasted background). Probabilistic handling of the image templates can improve the sensitivity but reduces the likelihood of successful recognition. Grouping requires good feature extraction, which is usually assumed via manual selection or images with special objects. The search tree can be reduced by using attributes of the object model such as surface characteristics but still requires high processing power. Invariant features (invariant to specific perspective distortions or to illumination) claim robustness, however perfect segmentation of the outline is assumed, an equally difficult problem. A promising approach is to use several cues and many local features that are statistically grouped to indicate object existence. The integration of recognition methods into visual servoing systems has not been achieved, since methods are complex and not reliable. Two exceptions are and regularly invokes a recognition scheme for reinitialisation. The idea is to exploit model knowledge. In most approaches this is done purely for the tracking step. Another typical approach to improve initialisation over the methods using simplifying constraints is to enhance tracking or segmentation methods to enable the initialisation. In summary, the initialisation of tracking is most of the time achieved by using simplifying constraints. Promising roads of work are fast object recognition approaches, methods to reliably extract features using cue integration and the goal directed use of modeling knowledge. Open problems in object detection relate to extraction of shape and structure of objects and relating them to known objects [4].

Visual servoing - arms and platforms The continuous control of a mechanism using visual input is referred to as Visual Servoing. It means to control the pose of a mechanism in a closed loop (e.g., the gaze direction of the end-effector) using the input of a machine vision system. Sometimes the term vision-based control of motion is used. Thus, apart from image processing and computer vision, visual servoing also requires techniques from control theory. Hence, visual servoing consists of two intertwined processes: tracking and control. In addition, the system may also require an automatic initialization procedure which may include figure–ground segmentation and object recognition, as outlined above. In the robotics community, visual servoing has been used to control the movement of robotics arms as well as mobile robots. In terms of camera configurations and their number, there are examples of both single and multiple cameras, that are either fixed in the workspace or are attached to the robot. Cameras fixed in the workspace may additionally be attached to a pan-tilt unit or another robot. The aim of visual servoing is twofold. On the one hand, visual servoing makes it possible to follow arbitrary object motions. On the other hand, it becomes possible to control the motion towards an arbitrary object location when seeing the direct relation between robot end-effector and the object. Hence, visual servoing eliminates the requirement to calibrate the camera robot system. It can be shown that two cameras using standard calibration parameters are sufficient for accurate robot control, This is achieved by either seeing the robot and the object within the images or by mounting the camera(s) directly on the robot end-effector [5].

Conclusion

Machine vision is quite an ambiguous subject. On the one hand, there are impressive results in this area, and many tasks have been solved. Machine vision systems cope with the automation of production, video surveillance, analysis of medical images. On the other hand, machine vision is still far from human. Many heights have been reached, many more to come. Therefore, there are two views on the development of machine vision. Some say that the machines will reach unprecedented heights and will develop tremendous power, they will be ahead of man. Others argue that cars will never surpass humans, and machine vision will remain unsuitable for solving some problems where human intervention is necessary.

Given the difficulties and open problems in robotics vision, in particular robustness, one has to think about the general approach to robot vision. Possibly a consequence is to rather move towards a [predict-act-sense] approach following the active vision paradigm. While already stated decades ago, the strict consequences are little followed, as the review here indicates. Work on actively using the arm to segment objects or linking affordances to visual features are first starts. A reason is certainly, that in this context vision needs to be treated in a completely different way. It is not a standalone component that delivers valuable input. Vision is one possible sensor modality to achieve a certain robot task. The task of vision is to provide specific information about the environment and its purpose is directly linked with the intended action.

The imperfection of machine vision is due to technical reasons, but there is a rapid development of information technology and there are more and more solutions to technical problems [6].

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