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DEVELOPMENT OF A VISION SYSTEM FOR CALCULATING THE NUMBER OF PARTS

Abstract. The paper presents a vision system for calculating the number of parts on a conveyor belt. The system is designed to solve the problems of quality control and product counting in industrial production conditions. The system consists of hardware and software. The hardware includes a high-resolution camera that captures detailed images of objects, a lighting system for evenly illuminating objects for accurate segmentation and recognition, and a computer with sufficient computing power to process images in real time. The software includes machine learning algorithms implemented on the basis of modern libraries and frameworks, an image preprocessing module that includes noise reduction, contrast and normalization methods, an object segmentation module that highlights individual objects in an image, an object recognition module that classifies selected objects by type, an object counting module that determines the number of objects of each type. As a result, the system was tested on a set of images with details. The accuracy of the calculation was 98%. This system can be used in various industries to automatically count parts on conveyor belts.

Keywords. Vision system, parts counting, machine learning, conveyor belt, industrial production.

Introduction.

In modern industrial production, the tasks of quality control and product counting are among the most important. Manual control does not always provide the required accuracy and speed, which leads to defects, losses and reduced productivity.

Technical vision systems based on cameras and machine learning algorithms allow you to automate these tasks, providing high accuracy, speed and efficiency.

The purpose of this study is to develop a vision system for counting the number of parts on a conveyor belt. At the same time, the objectives of the study include:

- analysis of existing machine vision methods and algorithms for counting objects;
- selection of hardware (cameras, lighting) for the system;
- development of software for image processing and counting of details;
- testing and optimization of the system.

The scientific novelty of the research is a new algorithm for counting parts, which has high accuracy and speed of operation. The developed system can be applied in various industries for automatic counting of parts on conveyor belts, which will improve the accuracy and speed of control, reduce the number of defects, increase labor productivity, and optimize production processes.

Materials and methods.

Vision systems usually include several key components.

The first is the imaging subsystem. This component includes image capture equipment such as video cameras or other sensors. The imaging subsystem is responsible for collecting visual information from the environment.

Next, image analysis algorithms, which make up a set of methods and procedures for processing and analyzing the obtained images. These algorithms are used for object recognition, feature extraction, classification, and other operations aimed at obtaining the necessary information from visual data [1].

Then, a computing system that includes computing equipment (computers, microcontrollers, etc.) performs image analysis algorithms. This system processes the received data, makes decisions and, depending on the tasks assigned, manages other components of the system.

All these components work together to create automated systems capable of perceiving and analyzing visual information in real time. Such systems are used in various fields, including industry, medicine, transportation, security and others.

To write software code that includes a machine vision algorithm, the Python programming language was chosen, since this language is one of the most popular for the development of technical vision systems. This choice is due to the following main objective reasons.

Firstly, Python has a rich set of libraries and frameworks specifically designed for the development of vision systems such as OpenCV, TensorFlow, Keras, PyTorch, etc. [2]

Secondly, Python has sufficient performance to develop real-time vision systems.

And finally, thirdly, Python is a cross-platform language that allows you to develop vision systems running on various operating systems.

In addition to the above, Python has the following advantages:

- Python code is easy to read and understand, which makes it easier to maintain and refine;
- Python allows you to quickly create prototypes of systems, which speeds up the development process;
- Python allows you to develop both simple and complex vision systems.

Results.

Thus, Python is the most optimal choice of programming language for developing a vision system for counting the number of parts. First of all, you should import the necessary libraries:

```
import cv2
import numpy as np
import imutils
```

Here 'cv2' is the OpenCV library for computer vision, 'numpy as np' is the NumPy library for numerical operations, and 'imutils' is an auxiliary function for OpenCV [3].

OpenCV is actually a standard library in the field of computer vision. It has such key characteristics as rich functionality, which includes more than 1000 functions and algorithms for image processing, object recognition, machine learning and much more. OpenCV is one of the most popular libraries in the field of computer vision and image processing.

Its active use in the industry and an active developer community attest to its wide acceptance. In addition, OpenCV is an open source project, which allows developers to freely use, modify and distribute the library in accordance with the license. Bindings for various programming languages are available based on OpenCV, including Python, Java, C#, and others. This makes it easier to use the library in various development environments. At the moment,

OpenCV continues to actively develop, including new functions and algorithms, as well as support for new technologies and standards [4].

Overall, this library remains one of the key tools for computer vision developers and plays an important role in the progress of this field.

Although OpenCV is the largest and most widely used library, other specialized libraries provide opportunities to solve highly specialized tasks in a more efficient and optimized form. The choice of a library depends on the specific requirements of the task and the specifics of the project [5].

OpenCV is distributed under the BSD license, which means free and free use in open and closed projects. It is not necessary to fully embed the library in the project; developers can use individual code snippets. OpenCV mainly implements basic computer vision operations, which makes it a low-level library. To solve complex tasks, developers must combine the provided blocks and build more complex applications based on them.

The following is the definition of the ‘count_bolts_nuts’ function. This function performs the detection of parts, namely bolts and nuts in real time using a video stream from a webcam [6].

```
def count_bolts_nuts():  
    # ...  
  
if __name__ == "__main__":  
    count_bolts_nuts()
```

Then the video stream is initialized: the connection to the camera is opened by default (index 0) using ‘cv2.VideoCapture’; the bolt and nut counter is initialized.

```
cap = cv2.VideoCapture(0)  
bolt_count = 0  
nut_count = 0
```

There is a video processing cycle, i.e. frames from the video stream are continuously captured in the loop.

```
while True:  
    ret, frame = cap.read()
```

Images are processed in three stages:

- converting the frame to grayscale;
- the use of median blur to reduce noise;
- Application of the Canny edge detector to search for boundaries.

```
gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
blurred = cv2.medianBlur(gray, 5)
edges = cv2.Canny(blurred, 50, 150)
```

Then there is the process of searching for contours in the image.

```
contours, _ = cv2.findContours(edges, cv2.RETR_EXTERNAL, cv2.CH
```

After that, the found contours are analyzed and the objects are counted.

```
for contour in contours:
    # ...

# Обновление счетчиков на кадре
cv2.putText(frame, f'Bolts: {bolt_count}', (10, 30), cv2.FONT_H
cv2.putText(frame, f'Nuts: {nut_count}', (10, 70), cv2.FONT_HER
```

This code iterates over each contour and calculates its area and center, classifies the object based on its area, draws contours and centers on the frame, and updates the counter [7].

As a result, annotated frames with object counts are displayed on the screen.

```
cv2.imshow('Object Detection', imutils.resize(frame, width=800))
```

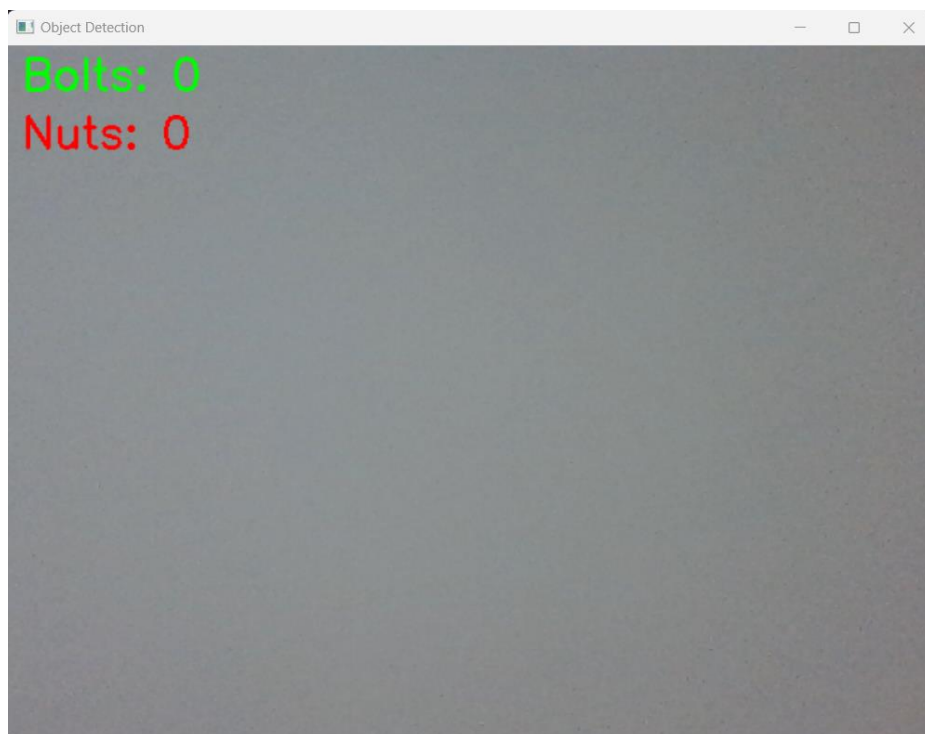
To break the cycle, press the 'q' key.

```
if cv2.waitKey(1) & 0xFF == ord('q'):
    break
```

After that, all resources are released and the connection to the camera, as well as OpenCV windows, are closed.

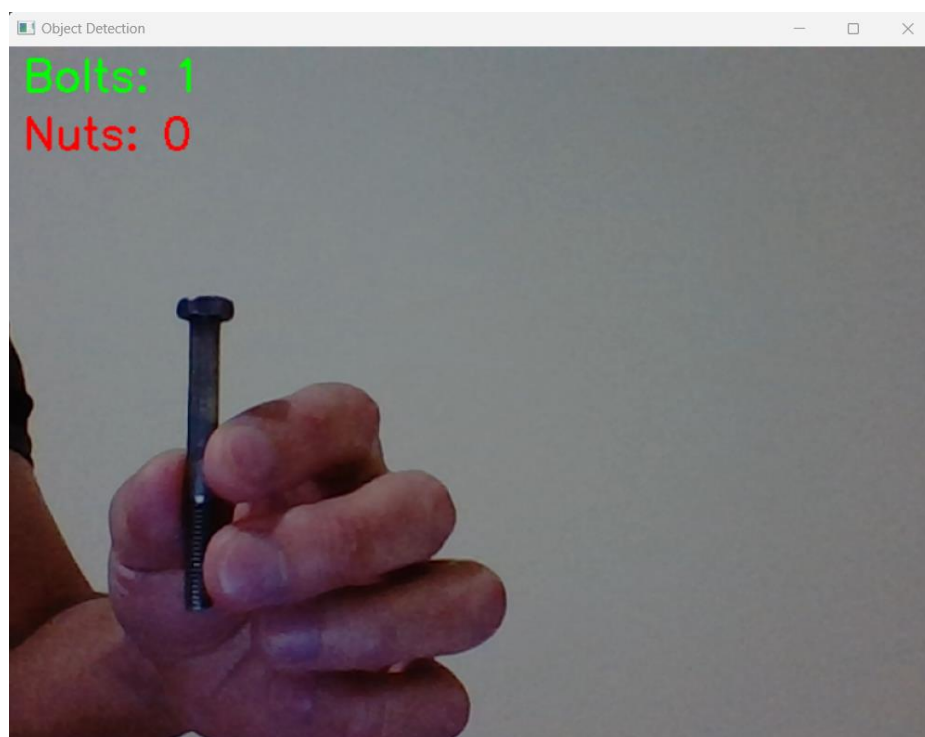
```
cap.release()
cv2.destroyAllWindows()
```

During the launch of the above code, a window with a bolt and nut counter appears.



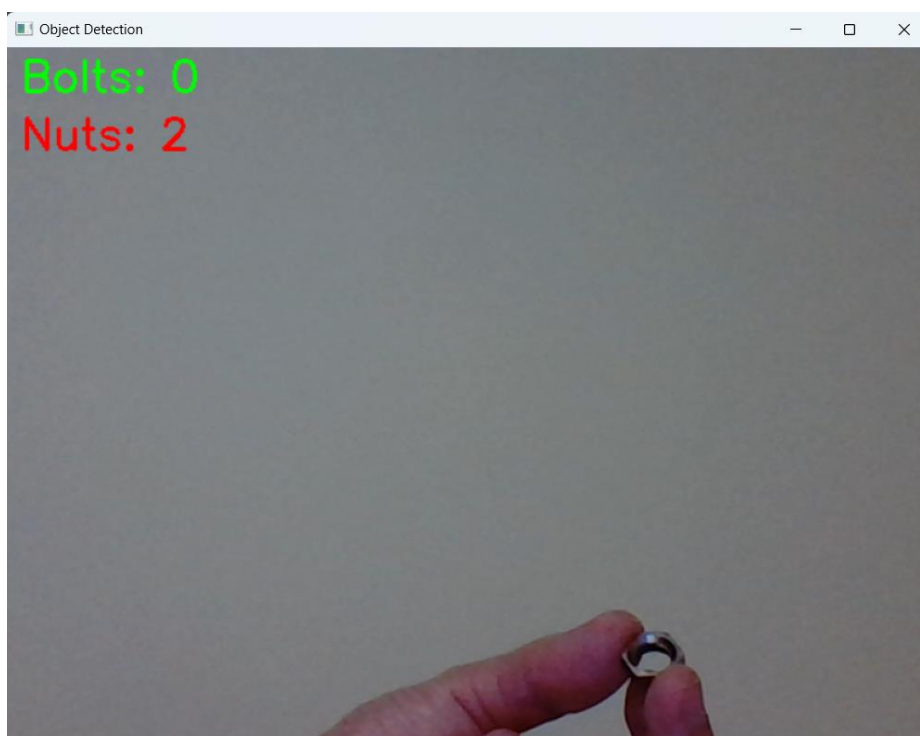
Drawing 1

Depending on which detail appears in front of the camera, the program recognizes and automatically counts their number in order.



Drawing 2

At the same time, the number of bolts and nuts is counted separately, and the counter is regularly updated.



Drawing 3

Discussion.

The result of the research work is a vision program for automated accounting of parts. Thus, the research and development of a vision system includes the following stages:

- analysis of the current process of accounting for details and an overview of similar hardware and software solutions;
- formulation of the basic requirements and recommendations for the vision system to account for details;
- an overview of digital image processing methods used in vision systems;
- development of a functional scheme of a vision system for accounting for details;
- analysis of computing devices for image processing and control, with the choice and justification of application in the system being created;
- development of the software part of the vision system, including the proposal of a method for identifying distinctive features. Confirmation of the effectiveness of the proposed correction method;
- software implementation of saving information about recognized details in the database, with the possibility for the user to view the history for a certain period of time [8].

Conclusion.

During the initial testing of the program, problems were identified in recognizing parts that have a similar appearance. Low accuracy was observed, manifested in a small percentage of deviations (not exceeding 1-2%) between the best and the smallest matches among the details from the database.

Nevertheless, all the tasks have been successfully completed, and the purpose of the study has been achieved. In the long term, there are opportunities for further development of this work.

At the moment, the model does not implement the functionality of recognizing two or more objects that may be in the field of view, touching or overlapping each other.

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БӨЛШЕКТЕР САНЫН САНАУ ҮШІН ТЕХНИКАЛЫҚ КӨРУ ЖҮЙЕСІН ӘЗІРЛЕУ

Андатпа. Жұмыста конвейер лентасындағы бөлшектердің санын есептеуге арналған техникалық көру жүйесі ұсынылған. Жүйе өнеркәсіптік өндіріс жағдайында сапаны бақылау және өнімді санау мәселелерін шешуге арналған. Жүйе аппараттық және бағдарламалық құралдан тұрады. Аппараттық құрал объектілердің егжей-тегжейлі кескіндерін түсіруге арналған жоғары ажыратымдылығы бар камераны, дәл сегменттеу және тану үшін объектілерді біркелкі жарықтандыруға арналған жарықтандыру жүйесін және нақты уақыт режимінде кескіндерді өңдеу үшін жеткілікті өңдеу қуаты бар компьютерді қамтиды. Бағдарламалық құралға заманауи кітапханалар мен фреймворктар негізінде іске асырылған машиналық оқыту алгоритмдері, шуды азайту, контраст және қалыпқа келтіру әдістерін қамтитын кескінді алдын ала өңдеу модулі, кескіндегі жеке нысандарды таңдайтын нысанды сегменттеу модулі, таңдалғандарды жіктейтін объектіні тану модулі кіреді. нысандар түрі бойынша, әрбір түрдегі нысандардың санын анықтайтын объектілерді санау модулі. Нәтижесінде жүйе егжей-тегжейлері бар суреттер

жинағында сынақтан өтті. Санау дәлдігі 98% құрады. Бұл жүйені конвейерлердегі бөлшектерді автоматты түрде санау үшін әртүрлі салаларда қолдануға болады.

Түйінді сөздер. Техникалық көру жүйесі, бөлшектерді санау, машинаны оқыту, конвейер лентасы, өнеркәсіптік өндіріс.

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РАЗРАБОТКА СИСТЕМЫ ТЕХНИЧЕСКОГО ЗРЕНИЯ ДЛЯ ПОДСЧЕТА КОЛИЧЕСТВА ДЕТАЛЕЙ

В работе представлена система технического зрения для подсчета количества деталей на конвейерной ленте. Система разработана для решения задач контроля качества и подсчета продукции в условиях промышленного производства. Система состоит из аппаратного и программного обеспечения. Аппаратное обеспечение включает в себя камеру с высоким разрешением, обеспечивающей захват детализированных изображений объектов, систему освещения для равномерного освещения объектов для точной сегментации и распознавания и компьютер с достаточной вычислительной мощностью для обработки изображений в реальном времени. Программное обеспечение включает в себя алгоритмы машинного обучения, реализованные на основе современных библиотек и фреймворков, модуль предобработки изображений, который включает в себя методы шумоподавления, контрастирования и нормализации, модуль сегментации объектов, который выделяет отдельные объекты на изображении, модуль распознавания объектов, который классифицирует выделенные объекты по типу, модуль подсчета объектов, который определяет количество объектов каждого типа. В результате система была протестирована на наборе изображений с деталями. Точность подсчета составила 98%. Данная система может быть применена в различных отраслях промышленности для автоматического подсчета деталей на конвейерных лентах.

Ключевые слова. Система технического зрения, подсчет деталей, машинное обучение, конвейерная лента, промышленное производство.

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