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Görüntü İşleme ile Mekik Koşusu Analizi

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ÖZET

Günümüzdeki teknolojik gelişmelerin ışığında artan oto kontrol sistemleri talebi, doğru ölçüm ve analiz ihtiyaçları gibi gereksinimleri karşılayabilecek insansız kontrol mekanizmaları tasarlamak ve hayata geçirmek ana hedeftir. Geliştirilen yazılım ile kapalı spor salonlarında mekik koşusu yapan sporcuların bir kamera yardımı ile süre analizini yapma ve bu analizleri bilgisayar ortamında saklama hedeflenmiştir. Mevcut problem üzerinde oturmuş bir çözüm bulunmamaktadır. Benzer olarak trafikteki yayaların takibi projeleri vardır ve bunlar üzerindeki çalışmalara temel alınmıştır. Bu tez çalışmasında öncelikle, görüntü içerisindeki hareketli objeler yakalanır, sonrasında belirtilen renk filtresine uygun görüntülerin takibi yapılır. Yapılan takip sonucu, tur süreleri gibi veriler saklanmaktadır. Yapılan denemeler sonucu sporcuların verilerinin başarılı bir şekilde ölçüldüğü ve saklandığı gözlemlenmiştir.

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Shuttle Run Analysis with Image Processing

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ABSTRACT

Increasing auto control systems in the light of today's technological developments, designing unmanned control mechanisms that can meet requirements such as the need for accurate measurement and analysis is the main goal. With the developed software, it was aimed to make time analysis of the athletes with shuttle running in indoor sports halls with the help of a camera and to store these analyses in the computer environment. No solution is available on the current problem. Similarly, there are prospective projects of traffic in the traffic bases and these are based on the work on them. In this thesis study, firstly moving objects in the image are captured, followed by images that match the color filter specified later. As a result of follow-up, the data such as lap times are stored. The end result is that the athlete's data have been successfully measured and stored.

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1. INTRODUCTION *(GİRİŞ)*

The rapid development of technology is to use automation systems to speed up work and reduce the error rate to a minimum. These rapid progress and automation systems and proven technological interest allow the sport industry to evolve with technology. With the camera systems used, the error rates are tried to be minimized. As an example, the referee used in the football, goal line technology, has recently increased in order to calculate the running distance of the soccer player. In addition to reducing the error rate, people continue to work on systems that will make their jobs easier. Basically, athletics can calculate running times, average speed calculation, and so on.

In the studies carried out within the scope of the project, it will alleviate the human burden and benefit from the computer based systems which will reduce the problems that may be caused by the human beings to the lowest level. It is aimed that the methods such as the calculation of the running times we mentioned earlier can be used by everyone by reducing the base and the system will be widespread on this side.

The aim of our project is to transfer the running times of the athletes who run shuttles to the computer environment by measuring the running times with the help of a camera. With these periods transferred, it is desired to reduce the workload of the trainers as well as to facilitate the follow up of the athletes' development.

Today, in order to provide similar inspections, it is possible to perform walking or running measurements using motion detectors, time calculations made with the cameras attached to the starting and ending lines in athletics, and motion detectors. However, the installation of the equipment and the surplus of the sensors make these systems expensive. However, the operation of these systems is also difficult. Today, it is determined that the systems which have high cost, difficult to install and apply, will be filled, and that there is an increase in the number of systems with computers. The installation of computer-based systems is easier and more cost-effective than other systems. Without the need for additional equipment from the camera, the data of the athletes can only be obtained using image processing techniques.

In this study, it is aimed to measure and store the data of the athletes who run shuttle running. A color filter will be used to distinguish the persons who are to be found and tracked in the image by using video cameras and using various image processing techniques to deliver this solution to the solution.

Video cameras are designed to be easily accessible, providing superiority over solutions such as laser, infrared camera, and radar in the way of expanding the system to be designed. Since video cameras do not emit any signals, it is not possible for them to interact with electromagnetic and fundamental noise. The fact that video cameras are not influenced by ambient variables provides a significant advantage over systems with radar systems and infrared cameras [1].

2. LITERATURE ANALYSIS *(LİTERATÜR TARAMASI)*

There are many methods in the literature for object detection in real time image. All of these methods have their own advantages and disadvantages. These areas directly affect the desired criteria in the project. If the desired objects in the project are in a certain shape or contain certain symbols, it can be filtered through the colors if they contain more than one object that is directly captured, moving and not of a certain shape.

Due to the widespread use and easy access of video cameras, today, it gives superiority to other solutions such as radar, laser, infrared. The sensitivity of infrared cameras to changing ambient temperatures has disadvantages compared to video cameras, such as the difficulty of detection in environments where human and ambient temperature are close to each other. In addition, it is not possible for video cam- era to interfere with the images contained in the media because they do not emit a sign and do not receive any sign from the medium [2]. Based on these, video cameras are at the forefront as the most appropriate solution.

For human detection systems, motion recognition and tracking, shape-based methods, and distance-based approach and background extraction are the most widely used methods [1]. During the detection, shape model and hiking analysis are foreground. Motion information is extracted by analyzing the frames that come in the continuous stream. With this method it is not possible to detect spans with a fixed position in the image [3].

The pedestrian detection method with stereo image base is used for separation of the objects on the front panel from the backplane. Shadow, light and superimposed objects are less affected. Using depth-of-field video cameras to obtain depth information, objects appear in the front plane. Trained systems using artificial neural networks and objects that are pedestrian are separated from other objects [4].

The periodicity of human movements is an important advantage in the analysis of walking people, particularly in springtime when walking horizontally relative to camera angle. In order to be able to operate the system with the minimum error rate, it is necessary to analyze the image taken well and take the view of the beam correctly.

The most important thing in this method is that the person is walking on the horizontal level. It is not possible to perceive stationary arcs with this system [5].

In the determinations made by the figure-based approach, it is compared with the human shapes previously defined in the image and recorded in the database. Pedestrian movements are rarely used. An unstable background problem does not have to be dealt with. In the projects where this method is used, calculations are very costly if the preliminary information about human form is insufficient [6].

Motion information is extracted by analyzing possible regions in consecutive frames in the flowing image. Detection of persons who are stationary in the image with successive images is not possible with motion information extraction method [3]. For this reason, the determinations made on a single frame are the foreground as a general solution in both cases.

The lower body detection method is used in situations where the upper part of the lid is not detectable due to the background, light and intensity. In many studies, the leg part, which is the lower part of the body, is not used as a separate fixing element in pedestrian detection. Because the legs do not allow too many feature sets to be detected. Studies done in the literature [7] [8] [9] generally use pedestrian detection together with the upper body and whole body information together or separately. Calculation is made by moving under the lower body. An economic video environment that identifies the pedestrians to change the motion vectors of Bacağ was followed immediately by pedestrian detection [10].

In the upper body region method, by separating the upper body parts; for example, by identifying the arms, head and body separately, and using the following relative positions of these parts, applying the joining and fixing approach [11], there are studies that use a single identifier for the upper body region [7] [8] [9].

Whole body detection is not possible in many cases. The different background, obstruction or concealment of the upper or lower body makes it impossible to detect the whole body from time to time. However, whole body detection gives information close to the origin of the donor. Therefore, in the studies done in the literature [7] [8] [9] pedestrian detection is mainly emphasized by using whole body knowledge.

3. METHODS USED *(KULLANILAN YÖNTEMLER)*

The shuttle run analysis typically comes in four parts. The first is the capture of the objects in the image, the second is the separation of the captured objects by the color filter, the third is person's movements are followed and finally the transfer and storage of the data to the computer environment at the end of the run. Image processing techniques are used to perform these operations. For this reason, it is necessary to examine image processing techniques.

3.1. Image Processing Methods Used *(Kullanılan Görüntü İşleme Yöntemleri)*

Image processing is a computer operation designed to change the measured or recorded electronic (digital) image data in accordance with the purpose of the electronic medium (with the help of computers and software). Image processing is mainly used to process existing images, ie, modify, alienate, or improve existing images and graphics [8].

3.1.1. HSV Color Space *(HSV Renk Uzayı)*

HSV color space defines color by Hue, Saturation and Saturation (Value) terms. Although it uses a mixture of RGB colors, HSV uses color, saturation, and brightness values. Saturation refers to the brightness of the color when determining the vitality of the color. The brightness value is zero when the color and saturation values for the black color in HSV space can take any value between 0 and 255. In white, the brightness value is 255. Figure 1 shows the RGB space.

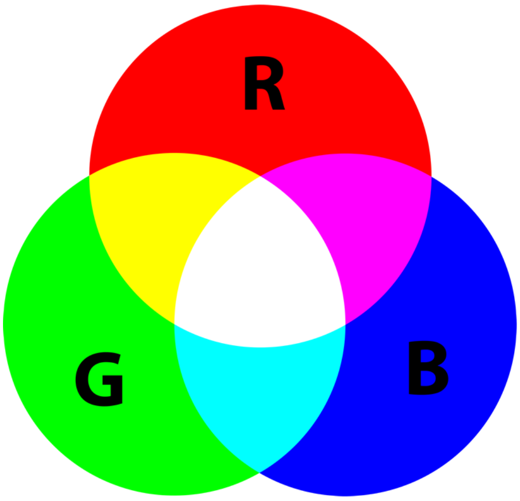

Figure 1. RGB color space *(RGB renk uzayı)*

In any computer image processing application, it is more convenient to use the HSV color space when we want to distinguish a particular color object. This is because, unlike using RGB, colors can be distinguished more precisely by applying a threshold value using only HUE (color) value. Figure 2 shows the HSV space.

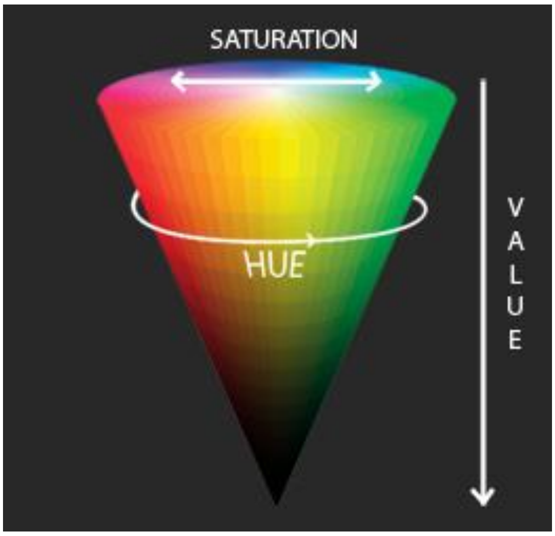

Figure 2. HSV color space *(HSV renk uzayı)*

3.1.2. OpenCV *(OpenCV)*

OpenCV (Open Source Computerized Video Library) is published under a BSD license and is therefore free for both academic and commercial use. It has C ++, Python and Java interfaces. Supported on Windows, Linux, Mac OS, iOS and Android platforms. OpenCV is designed for a powerful focus on computational efficiency and real-time applications. The library written with Optimize C / C ++ can benefit from multi-core processing. When enabled with OpenCL, it can take advantage of the hardware acceleration of the underlying heterogeneous computing platform [11].

The library has more than 2500 optimized algorithms, including a comprehensive array of both classical and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and identify faces, define objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, generate 3D point clouds from stereo cameras, and combine images in high resolution. OpenCV has more than 47 users with over 14 million downloads. It is widely used by companies, research groups and government bodies [12].

3.1.3. Image Matrix Storage *(Görüntüyü Matrise Depolama)*

There are many ways to get digital images from the digital world: digital cameras, scanners, computerized tomography and magnetic resonance imaging. In any case, our views are images. However, what we are saving when converting our digital devices are numerical values for each point of view [13]. OpenCV is a library whose main focal point is to process this information. For this reason, the first thing you should be familiar with is how OpenCV stores and processes images [14].

3.1.4. OpenCV Mat / Basic Image Library *(OpenCV Mat / Temel Görüntü Kütüphanesi)*

Mat is a class with two data parts basically: a pointer to a matrix (depending on the method chosen for storage, takes any size), including the matrix title (the matrix's size, the method used to store the matrix, the information of the stored matrix etc.) and the pixel values. The matrix header size is fixed, but the size of the matrix can vary from image to image.

In the first part of the project, it uses three main Mat variants to store each image taken by the camera, to store the HSV converted image and to store the binary threshold image. The aim here is to pass the image filtered with HSV values to the binary threshold display screen. Thus, the HSV values of the objects to be processed in the image can be obtained.

3.1.5. OpenCV FindContours *(OpenCV FindContours)*

FindContours is a function to find the contours of objects in the picture. This function retrieves the contours from the binary image using the algorithm. Contours are a useful tool for shape analysis, object recognition and recognition [15].

3.1.6. OpenCV Moments *(OpenCV Moments)*

The notion of statistics and mechanics of moment is borrowed in computer environment to describe a view. For the image with pixel intensities I (x, y), the raw image moment is calculated by Mij.

$$Mij=\sum x \sum y I(x,y) \qquad (1)$$

In calculating a typical image moment, the I (x, y) image is first converted to a series of vectors by calculating gray scale. Then a corner or edge detector is used to reduce the image to a series of bevel multiplication points. The spatial distribution of these points characterizes the image because an image with different visual content will have a different spatial distribution of measurable multiply points [18].

3.1.7. OpenCV Morphops *(OpenCV Morphops)*

Morphological transformations are some simple processes based on the shape of an image. Conversions are performed on binary images. This process requires two inputs, one is our original image and the second is called the configuration element or kernel that determines the nature of the process. There are two basic morphological operators, Erosion and Dilation.

The basic idea of Erosion is similar to that of soil erosion, but it erodes the boundaries of the object in front. A pixel in the original image will be counted as 1 only if all pixels underneath the kernel are 1, otherwise it will be erased (reset). All pixels near the border will then be discarded depending on the size of the nucleus. This reduces the foreground object's size and size, leaving only the white region in the image. Removing tiny white voices is useful for separating two linked objects.

Dilation is the opposite of Erosion. Here, if a pixel below the kernel value is 1, it will be counted as 1 on the other pixels. Thus, the size of the white region, ie the object in front, is increasing. In situations like noise reduction, follow Dilation after Erosion. Erosion removes the white voices but at the same time the object is shrunk. After dilation, the object area becomes close to its old size and is free from noise.

4. EXPERIMENTAL STUDIES *(DENEYSEL ÇALIŞMALAR)*

In this section, the project that is being worked on and designed within the scope of the thesis will be described with the other name "Analysis of Image Processing and Shuttle Run". In this study, the Shuttle Run

Analysis consists of three parts. These sections are the introduction of the colors to be filtered, the application of the filters on the real time captured image, the capture of the desired objects and the follow up. It has been envisaged that the system can be used in real time without compromising system speed and detection quality if certain rules and restrictions are followed in pedestrian detection and detection using a single camera [14].

4.1. Obtaining HSV Values *(HSV Değerlerinin Elde Edilmesi)*

The first step of the process is color analysis. The images in the color form taken into the application contain millions of colors. These colors are derived from the main colors red, green and blue. Besides, every color saturation and brightness in the image will help us in detecting the objects. The classification of the classifier used for a particular feature set directly affects the required speed and quality. In general, there is an inverse relationship between speed and quality [15].

If you need to detect and classify multiple objects within a project, a color filter is needed. Thanks to this color filter, objects are captured according to colors already introduced to the project and specific filters are applied on these objects.

The color analysis part, which is the first step of the project, is made in HSV format. HSV format is applied because it is more sensitive than RGB. When RGB is processed with only color values, the brightness and saturation values of HSV are evaluated. In the designed software, the HSV values are obtained from the area selected by the user with the mouse cursor over the real time image. The smallest and largest HSV values in the selected area are used.

Figure 3 shows the Trackbar window created to show the HSV values. The minimum and maximum HSV values of the user-selected object are shown here.

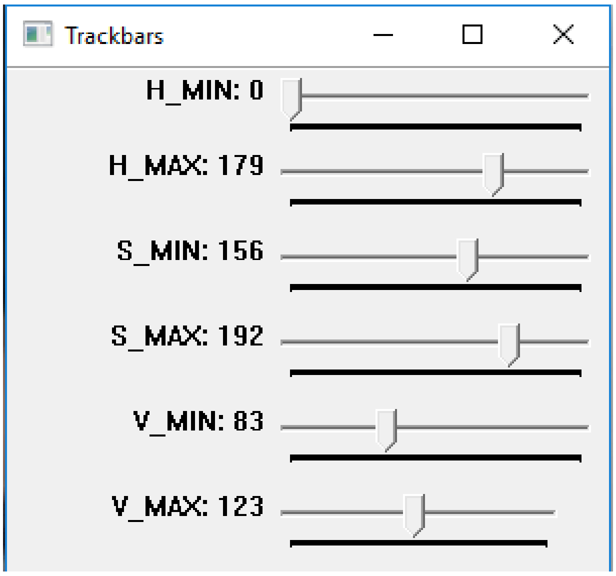

Figure 3. Trackbar window showing HSV values *(HSV değerlerini gösteren Trackbar penceresi)*

In Figure 4. the user analyzes the HSV values of the region using the mouse in the real-time image. An area is selected with a mouse cursor to select a specific point and create a rectangle. The minimum and maximum HSV values within this area are transferred to the Trackbar window.

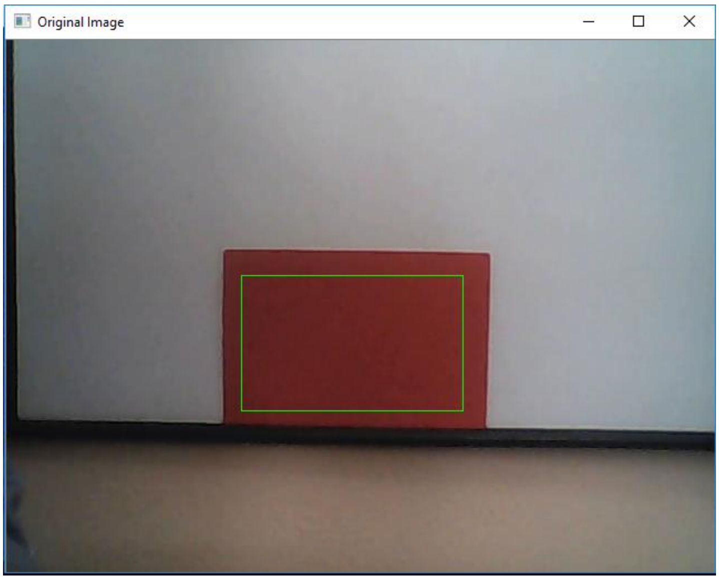

Figure 4. Using HSV values in the image using mouse cursor *(Fare imleci kullanılarak, görüntü içerisinde HSV değerleri elde edilmesi)*

The objects that match the HSV values obtained from the selected area are in the image frame shown in Figure 5.

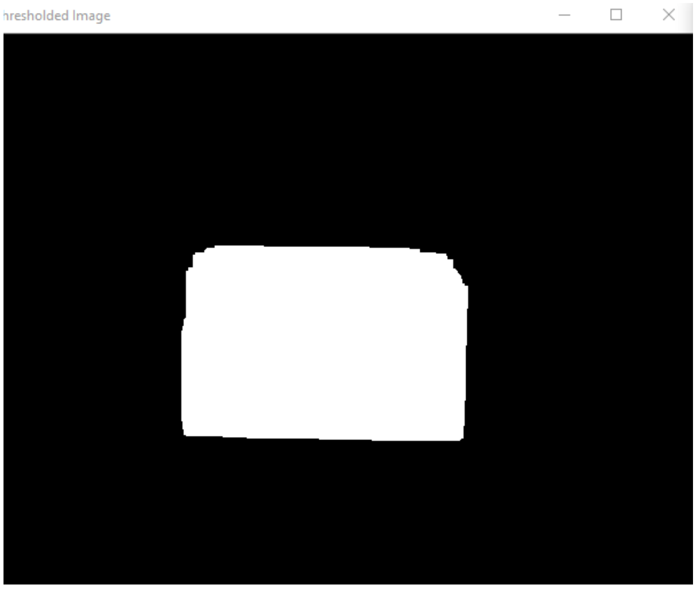

Figure 5. HSV values are analyzed in the resulting threshold image at the filtered region *(HSV değerleri analizi sonucu threshold görüntü de filtrelenen bölge)*

In the original image shown in Figure 6., objects that match the HSV values are tracked.

Figure 6. Analysis of the HSV values resulted in the filtered region in the original image *(HSV değerleri analizi sonucu orijinal görüntüde filtrelenen bölge)*

With the aid of C ++ in the designed software, a region of interest (ROI), which is an OpenCV function, is created by mouse movements. Once the ROI region has been created, all HSV values within the region are stored in a sequence. The minimum and maximum HSV values are displayed on the Trackbar after recording is finished. Taking these HSV values and real-time images, objects are traced and analyzed.

4.2. Matrise Storage of Images Acquired in Real Time *(Gerçek Zamanlı Olarak Alınan Görüntülerin Matrise Depolanması)*

What we save when converting images to digital devices is the numerical values for each point of view. These numerical values are held in the matrices. So we need to store the images in matrices that we will process on.

The features of the VideoCapture class, which is an OpenCV class, are used to store the image captured from the camera. A class for capturing video from video files, image sequences or cameras. The captured image is then recorded in a file called CameraFeed to be processed.

4.3. Catching Objets in the Image *(Görüntü İçerisindeki Objelerin Yakalanması)*

The second stage of the project is aimed at capturing the objects in the image and performing the necessary decomposition between the objects and the color filter to be applied. After finding the objects of the appropriate size that we can manipulate using OpenCV's FindContours object, we can proceed with color filtering. FindContours is a function to find the contours of objects in the picture. This function retrieves the contours from the binary image using the algorithm. Contours are a useful tool for shape analysis, object recognition and recognition [14].

The FindContours function works on morphologically processed images. The reason for this is to clarify the objects and to get rid of the noises as we have already explained in morphological processes. The function creates contours to keep the locations of the objects it finds, and keeps these contours in the variable contours. Another parameter, hierarchy, is used to separate objects that are overlaid in the image. Finally, there are two function-specific parameters for the contouring method and contour approximation method.

Within the project, the maximum and minimum dimensions of the soil are mentioned. The dimensions of the objects captured by FindContours are compared with these parameters, and if the object is found, the next step is to separate the objects with the color filter.

4.4. Observation of Desired Objects Using Color Filter *(Renk Filtresi Kullanılarak İstenilen Objelerin Takibi)*

As far as the project is concerned, the calculation of HSV values of the objects desired to be followed and the capturing of objects in the image have been carried out. In the final stage, the project will continue with the information obtained from these two phases. A class called Colours.h has been created to compare the HSV values of the captured objects and to access the locations of these objects. The minimum and maximum HSV values of the objects to be tracked are kept here.

At the end of the project, objects that match the HSV values previously placed in the project are marked among the objects. This marking consists of 3 steps. First, a circle was placed near the center of the observer. Secondly, the coordinates of the observed object image are shown. Finally, there is a text that we can also refer to as the name of the object that is followed. With this information, we have information about the color and position of the object. Then, using this information with the camera placed in the center of the object is followed. The object to be tracked in our project will be athletes. It is desired to conduct a follow-up and time analysis of the runners who will do the shuttle run. The analysis will be recorded on the computer. Thus, more reliable information will be obtained for both the athletes and the trainers, and it will make their jobs easier. In Figure 7, in the real-time image, two objects with HSV values matching the previously analysed values are captured.

Figure 7. Detection of objects with HSV values *(HSV değerleri verilen objelerin yakalanması)*

The simulations are prepared for the project to capture the objects given HSV values. In this simulation small plastic balls were used instead of athletes. The image was processed on real time basis and observed in two different media. Figure 8 shows an image of the first environment.

Figure 8. The image of the first environment where simulation is made *(Benzetimin yapıldığı ilk ortamın görüntüsü)*

It is seen that objects are filtered by HSV values during simulation. In order to obtain the correct HSV values, several tests were performed in the environment beforehand and the test results were simulated with the best values. Minimum HSV values for yellow ball 50,66,150 maximum HSV values 66,106,233, minimum HSV values for blue ball 107,108,69 maximum HSV values 114,204,209, minimum HSV values for green ball 16,111,168 maximum HSV values 26,175,239.

In the first simulation, the yellow ball (color3) was observed for 8 seconds, the green ball (color1) for 15 seconds and the blue ball (color2) for 14 seconds. These observations are likened to the tours in the shuttlecraft. During the shuttle run, each round starts a whistle and the second whistle is waited when the round is over. In this waiting period, the athletes have to pass the determined lines. Based on the time interval between the second whistle and the tiller, it is determined that the turon is over and the tour time is recorded. The console output of the calculated laps is shown in Figure 9.

Color	Min HSV	Max HSV	Lap Time
Yellow	50,66,150	66,106,233	8 second
Green	107,108,69	114,204,209	15 second
Blue	16,111,168	26,175,239	14 second

Figure 9. Calculated times in the first simulation environment *(İlk benzetim ortamında değerleri)*

In the second simulation, as shown in Figure 10, when the HSV values used during the first simulation are tried to be used, it is seen that the other balls can not be caught while the blue ball is caught. The HSV values are filtered not only by the color but also by the brightness and saturation. In the second environment, yellow and green colored balls are observed to be brighter. This event indicates that the tests need to be repeated when there is a change in the environment.

Figure 10. When the first environment values are used in the second environment *(İkinci ortamda ilk ortam değerleri kullanılırken)*

For the second simulation, the HSV values are again calculated as shown in Figure 11. The minimum HSV values for the yellow ball are 57,57.93 max. The HSV values are 76,116,171, the minimum HSV values for the green ball are 18,90,141 and the maximum HSV values are 31,152,195. A change has not been made for the blue ball. In the reconstructed simulation with these values, all the bubbles are captured with color filters as seen in Figure 11.

Figure 11. Image of second environment where simulation is made *(Benzetimin yapıldığı ikinci ortamın görüntüsü)*

In the second simulation, the yellow ball (color3) was observed for 7 seconds, the green ball (color1) and the blue ball (color2) for 9 seconds. The console output of the calculated laps is shown in Figure 12.

Color	Min HSV	Max HSV	Lap Time
Yellow	57,57,93	76,116,171	7 second
Green	18,90,141	76,116,171	9 second
Blue	16,111,168	26,175,239	9 second

Figure 12. Calculated times in the second simulation environment (İkinci benzetim ortamında hesaplanan süreler)

Tests were repeated 3 times under the same conditions and conditions. As a result, it was observed that the effect of the environmental variables was high and the tests had to be repeated if there was any change. When the tests are performed successfully, the system appears to be running at full efficiency.

5. RESULTS AND RECOMMENDATIONS (SONUÇLAR VE ÖNERİLER)

In the developed application, the aim is to reduce the workload of the trainers, and at the same time to reduce the error rate to the minimum in the time calculations made. In this direction, it is aimed to develop a software that allows the athletes to be followed in the image captured with the help of the camera. As a result of the developed software, the generated simulation environment and the correct tests done in this environment, it seems that the application works correctly and fully. If full efficiency is desired in different environments, it is necessary to repeat the tests to analyse ambient conditions.

When similar applications are examined, it is determined that the correct results are obtained if the appropriate amount of light is provided. The intent of the appropriate light condition is that the colors on the objects correspond to the brightness and saturation values contained in the HSV values. With proper environment and accurate lighting, the system works close to 100 percent. The system will operate in full efficiency if it is used with a fixed lighting in a closed gym.

As a result of this study, the workload of the trainers was reduced, and the error rate was reduced to the minimum in the time measurements to be made.

Motion recognition and tracking at the detection phase, distance-based approach and background extraction and shape-based methods are the most widely used methods in pedestrian detection systems [14]. As a result of this study, it is possible to calculate the velocities of all the pixels in the image and to follow the moving objects on the basis of the areas of these images, in order to ensure that the workload of the trainers is reduced and the time period to be performed is made more efficient and less costly in the future. The advantage of this method is

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that athletes will not need to wear different colors and color analysis. In future studies, this method will be tried and tested for any disadvantages.

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