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Motion Capture of Human for Interaction with Service Robot

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Abstract This article deals about the issue of the motion capture of human for interaction with service robots. In the framework of article were used the results of the Bachelor thesis, which dealt with this issue [1]. Motion capture is a rapidly emerging technology, via which is possible quickly, easily and mainly highly detailed to record movements of the scanned subject and continue to work with them and then to control service robots. The article discusses the methods motion capture and design three variant solutions of motion capture, from which was selected optimal variant on the basis of selected criteria and for the chosen variant was created algorithm.

Keywords: *motion capture, service robot, algorithm, MATLAB*

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1. Introduction

Motion Capture is a technology by which we can digitally record the movements of people, animals and things. This technology is used in practice, especially in the engineering industry. Its use is also in the military, science, health service, computer games and film industry. With this technology, animators and scientists can quickly, easily and very detailed record movements of subjects. By special software are transmitted these movements to control service robots [1,6].

2. Systems for Motion Capture

There are several possible systems for motion capture, which differ in method of sensing, properties but also the price. Systems for motion capture we can divide to systems, that use the mechanics-mechanical, magnetic and inertial motion capture and systems using the software to processing obtained data -optical motion capture [1,6].

2.1. The Systems for Motion Capture Using the Mechanics

2.1.1. The Mechanical Motion Capture

Mechanical motion capture systems directly track body joint angles and are often referred to as exo-skeleton motion capture systems, due to the way the sensors are attached to the body. Performers attach the skeletal-like structure to their body and as they move so do the articulated mechanical parts, measuring the performer’s relative motion. Mechanical motion capture systems are real-time, relatively low-cost, free-of-occlusion, and wireless (untethered) systems that have unlimited capture volume. Typically, they are rigid structures of jointed, straight metal or plastic rods linked together with potentiometers that articulate at the joints of the body. Some suits provide limited force feedback or Haptic input [2].

Figure 1. The mechanical motion capture Gypsy 6 [1]

2.1.2. The Magnetic Motion Capture

Magnetic systems calculate position and orientation by the relative magnetic flux of three orthogonal coils on both the transmitter and each receiver. The relative intensity of the voltage or current of the three coils allows these systems to calculate both range and orientation by meticulously mapping the tracking volume. The sensor output is 6DOF, which provides useful results obtained with two-thirds the number of markers required in optical systems; one on upper arm and one on lower arm for elbow position and angle. The markers are not occluded by nonmetallic objects but are susceptible to magnetic and electrical interference from metal objects in the environment, like rebar (steel reinforcing bars in concrete) or wiring, which affect the magnetic field, and electrical sources such as monitors, lights, cables and computers.

The sensor response is nonlinear, especially toward edges of the capture area. The wiring from the sensors tends to preclude extreme performance movements. The capture volumes for magnetic systems are dramatically smaller than they are for optical systems. With the magnetic systems, there is a distinction between “AC” and “DC” systems: one uses square pulses, the other uses sine wave pulse [3].

Figure 2. The magnetic motion capture Nest of Birds [1]

2.1.3. The Inertial Motion Capture

Inertial motion capture technology is based on miniature inertial sensors, biomechanical models and sensor fusion algorithms. The motion data of the inertial sensors (inertial guidance system) is often transmitted wirelessly to a computer, where the motion is recorded or viewed. Most inertial systems use gyroscopes to measure rotational rates. These rotations are translated to a skeleton in the software. Much like optical markers, the more gyros the more natural the data. No external cameras, emitters or markers are needed for relative motions, although they are required to give the absolute position of the user if desired. Inertial motion capture systems capture the full six degrees of freedom body motion of a human in real-time and can give limited direction information if they include a magnetic bearing sensor, although these are much lower resolution and susceptible to electromagnetic noise. Benefits of using Inertial systems include: no solving, portability, and large capture areas. Disadvantages include 'floating' where the user looks like a marionette on strings, lower positional accuracy and positional drift which can compound over time. These systems are similar to the Wii controllers but are more sensitive and have greater resolution and update rates. They can accurately measure the direction to the ground to within a degree. The popularity of inertial systems is rising amongst independent game developers, mainly because of the quick and easy set up resulting in a fast pipeline [4].

Figure 3. The inertial motion capture IGS-190 [1]

2.2. The Systems for Motion Capture Using the Software to Processing Obtained Data

2.2.1. The Optical Motion Capture

Optical systems utilize data captured from image sensors to triangulate the 3D position of a subject between one or more cameras calibrated to provide overlapping projections. Data acquisition is traditionally implemented using special markers attached to an actor; however, more recent systems are able to generate accurate data by tracking surface features identified dynamically for each particular subject. Tracking a large number of performers or expanding the capture area is accomplished by the addition of more cameras. These systems produce data with 3 degrees of freedom for each marker, and rotational information must be inferred from the relative orientation of three or more markers; for instance shoulder, elbow and wrist markers providing the angle of the elbow. Newer hybrid systems are combining inertial sensors with optical sensors to reduce occlusion, increase the number of users and improve the ability to track without having to manually clean up data [5].

Figure 4. The optical motion capture [1]

These systems for motion capture were compared and were selected systems for motion capture using the software to processing obtained data. On comparison these variants was used method based on pairwise comparison of variants [1].

3. Variant Solutions of the Systems for Motion Capture Using the Software to Processing Obtained Data

For this method motion capture were designed three variants of algorithm.

3.1. The First Variant of Motion Capture

Description of the flowchart of the first variant [1]:

1. use a black suit, on which will be marked color areas among which will measure the angle
2. reading image of human figure in a certain period of time

3. on selected object-for example on hand are rendered contours of the color areas
4. on the colored areas of the hand is determined the initial, ending point and center of gravity; these points are connected each other and through them will pass the lines; this cycle is repeated until the all contours and lines appear
5. in places, where the lines intersect, will be appear the joints
6. selection of objects, among which implements measurement of the angle
7. measuring the angle, the angle of each image is compared with the angle of the previous image in a very small time intervals

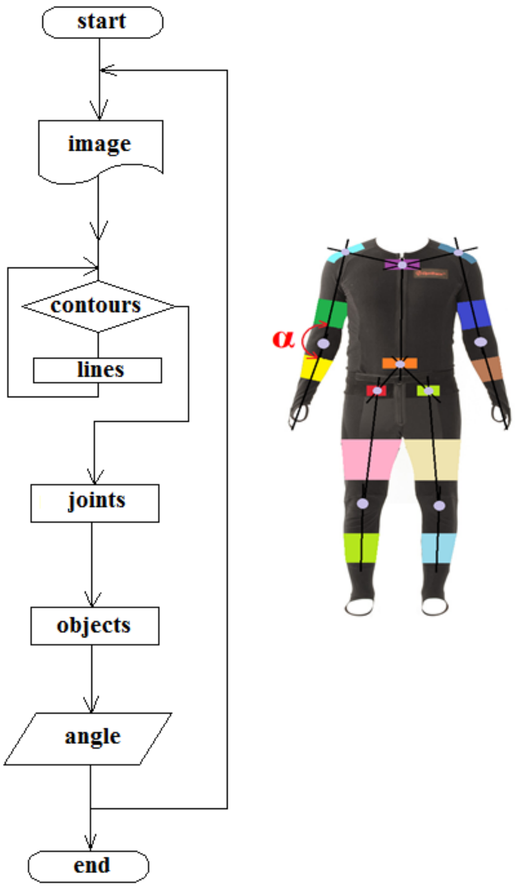

Figure 5. The flowchart of the first variant [1]

3.2. The Second Variant of Motion Capture

Description of the flowchart of the second variant [1]:
1. use a black suit, on which are active marks
2. reading image of human figure in a certain period of time
3. scanning active marks
4. connecting marks, this part of the cycle is repeated until connect all marks
5. in places, where the lines intersect, will be appear the joints
6. selection of objects, among which implements measurement of the angle-for example shoulder and forearm
7. measuring the angle, the angle of each image is compared with the angle of the previous image in a very small time intervals

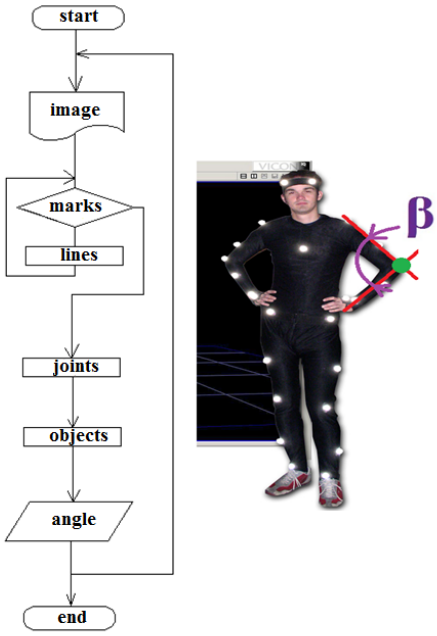

Figure 6. The flowchart of the second variant [1]

3.3. The Third Variant of Motion Capture

Description of the flowchart of the third variant [1]:
1. use a black suit
2. reading image of human figure in a certain period of time
3. thresholding-the process by which the objects in the image can be distinguished from background on the basis the luminosity value, we obtained a black and white image
4. rendering the individual contours of the human body
5. on individual contours are generated lines, which will be passes through the center of gravity, initial and ending point of the contour; this cycle is repeated until the all contours and lines render
6. scanning of default kinematics, which is calibrated with certain type of human figure
7. selection of objects, among which implements measurement of the angle
8. measuring the angle, the angle of each image is compared with the angle of the previous image in a very small time intervals

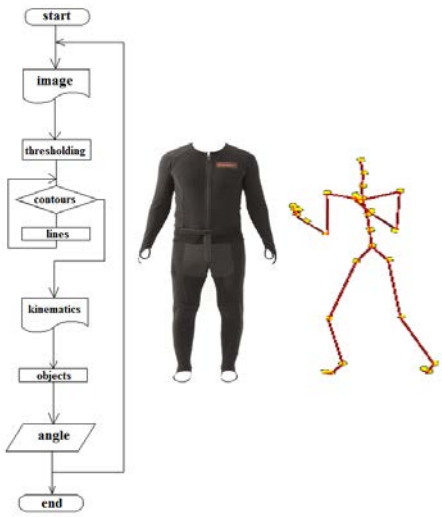

Figure 7. The flowchart of the third variant [1]

4. The Algorithm of the First Variant

To select the optimal variant was again used method based on pairwise comparison of variants. Each of these variants was reviewed on the basis of the selected criteria and as the optimal solution was chosen the first variant.

Sequence steps of algorithm the first variant in MATLAB [1]:

-reading image of human figure in a certain period of time

RGB = imread;
imshow(RGB);

Figure 8. Reading image of human figure [1]

-rendering the contours and lines on the colored areas

[B,L] = bwboundaries;
imshow
for k
boundary = B{k};
plot
end
boundary1= bwtraceboundary;
boundary2= bwtraceboundary ;
imshow(RGB);
plot(offsetX+boundary1,offsetY+boundary1);
plot(offsetX+boundary2),offsetY+boundary2);

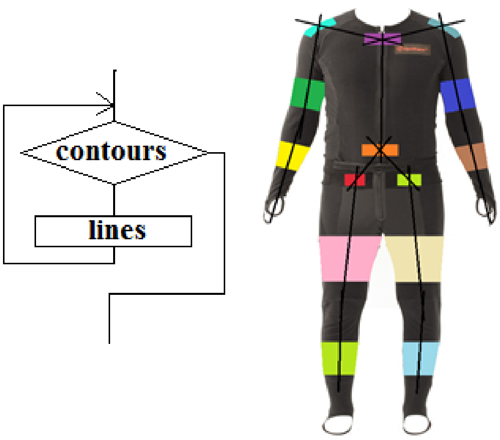

Figure 9. Rendering the contours and lines [1]

-rendering the joints in places, where the lines intersect

intersection = [1 ,-ab1(1); 1, -ab2(1)] \ [ab1(2); ab2(2)];
intersection = intersection + [offsetY; offsetX]

Figure 10. Rendering the joints [1]

-selection of objects, among which implements measurement of the angle

start_row
start_col
cropRGB = RGB;
imshow(cropRGB)
offsetX ;
offsetY ;

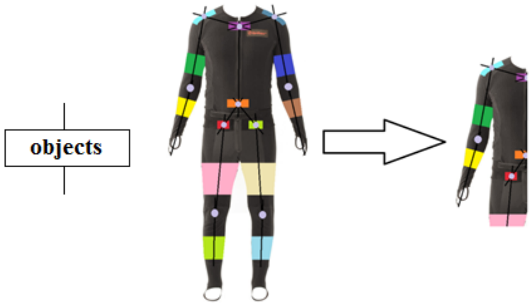

Figure 11. Selection of objects [1]

-measuring the angle among the rendered lines

vect1 = [1 ab1(1)];
vect2 = [1 ab2(1)];
dp = dot(vect1, vect2);
length1 = sqrt(sum(vect1.^2));
length2 = sqrt(sum(vect2.^2));
angle = 180-acos(dp/(length1*length2))*180/pi

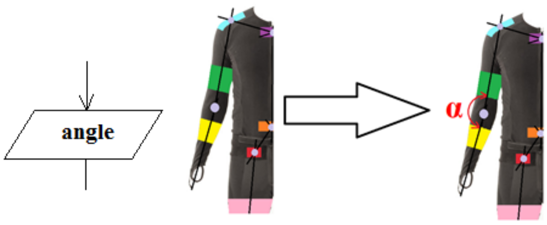

Figure 12. Measuring the angle [1]

5. Conclusion

The article explicate the issue of options motion capture and design methods how would be possible capture the movement of a person. In the first part, are analyzed the most commonly used systems for motion capture. The second part presents Variant solutions of the systems for motion capture using the software to processing obtained data and selection of the most suitable variant. The algorithm of optimal variant designed in MATLAB is necessary to tune and verify its functionality.

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