Pull-down Fitness Technique Analysis using Motion Capture

by Rossi Passarella

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Pull-down Fitness Technique Analysis using Motion Capture

R Passarella, A S Nugroho, and F N Arsyad

Department of Computer Engineering, Faculty of Computer Science, Universitas Sriwijaya, Palembang, Indonesia

Abstract. Exercise is an essential contributor to physical and psychological well-being. Regular exercise reduces many chronic diseases, such as heart diseases, diabetes, hypertension, obesity, etc. *Pull-down* is one of the Weight Training exercises. Engaging in physical activities such as Weight training, stretching exercises and aerobic exercises requires proper execution and awareness of the exercises to avoid bodily injuries and get maximal results. In this study, software that can analyse technique exercise of *Pull-down*. As research material, because of a degree, each human elbow is different, distribution data of *Trainer* elbow degree is calculated using measure standard deviation and displayed as a normal distribution graph. The method used in this study to analyse proper *Pull-down* exercise technique is compared to elbow angle *Trainee* with elbow angle *Trainer*. The output of this software is elbow angle, the correctness of the methods performed by the *Trainee*. The average percentage of accuracy from the results of testing the analysis software using the value of the angle of 56.87 ° ± 7 ° *Trainer* is 88%.

1. Introduction

Exercise is essential for human physical and psychological health. Regular exercise reduces the possibilities of chronic diseases, such as heart disease, diabetes, hypertension, obesity and other [1]. Doing sports such as weight lifting exercise, stretching exercise, and gymnastic require proper training techniques to avoid injury.

Pull-Down is one of the weight lifting exercises and trains several body joints which involving complex shoulder movement for example glenohumeral joint, scapulothoracic joint, hand elbow and designed to add muscle capacity from upper extremity and chest/torso [2]. This exercise is usually performed the first time when a person wants to shape their body into ideal or more muscular in fitness place because this exercise adds the capacity of Latissimus Dorsi muscles [3]. One of the ways for pull-down exercise is using fitness lat pull-down to get maximum result and minimalize shoulder injury during pull-down exercise, should follow proper training technique and guided by a Trainer [2] [4] [5].

2. Literature review

2.1. Related Research

One of the research related to this research is performed by [6], researching "Kinect based Physiotherapy system for home use". In his study, Haas et all built a system which used Kinect camera to detect the movement of the human body. To determine true or false exercise technique, they calculate the length of extremities and angle between joint using cosine rules[7][8][9][10].

Another related research, which was proposed by [4], in his study. also used Kinect camera to detect movement of the human body, [4] also use cosine rule to determine angle of each body joint, and to compare true or false exercise technique by comparing Trainee pattern data and Trainer pattern data using Warping Dynamic Time algorithm.

2.2. Feature Extraction

Feature extraction is a process of capturing feature object which can describe the characteristics of purpose, value which extracted in this research will be used as parameter, feature extraction step is a necessary process which useful for data processing, there are several feature extraction methods which are: form Feature, size feature, geometry feature, texture feature.

Feature extraction which used in this research only geometry feature extraction. Geometry feature is one of the extraction which process pixel image derived from data form, space properties, position and size

2.3. Pull-down

Pull-Down is an exercise of several body joints involving complex shoulder movement, for example, glenohumeral joint, scapulothoracic joint and elbow, and designed to add muscle capacity from the upper body/upper extremity and chest/torso. This exercise will give an advantage for athletes who want to improve their upper body strength and endurance. Strengthening the Latissimus dorsi and Glenohumeral muscle will be adding the ability of the individual to transfer movement between upper and lower extremities during activities such as swinging, throwing, and possibly running. [2].

Things which should aware of and usual mistake when pull-down exercise using a lat pull-down tool are divided into 3 part:

1. Downward Movement :
   Exhale at the moment when pulling down the bar and positioning to the front of the body until it reaches chin level. This movement should be carried out for 2 – 4 seconds [2]. The illustration about this movement shows in Figure 1.

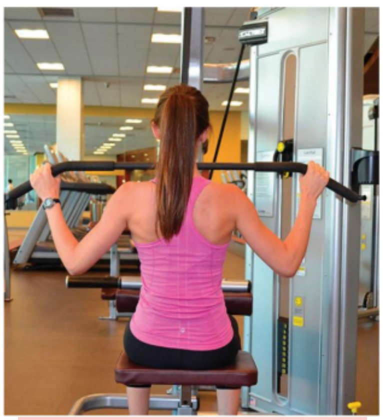

Figure 1. Downward Movement [2]

2. On upward movement:
   Take the breath while controlling shoulder firmly and stretching the elbow while the bar rises to its starting position until the angle straight back. This movement should be carried out for 2 – 4 seconds. [2]. Figure 2 is showing the upward movement.

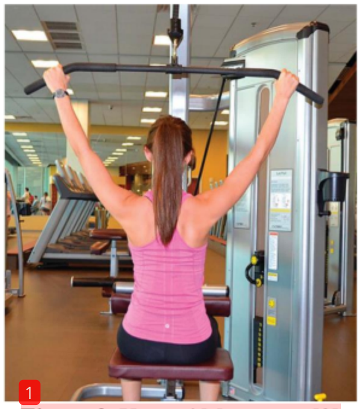

Figure 2. Upward Movement [2]

3. Body Position:
   When sitting position can only tilt backwards by 70 – 80 degree, try to position the neck and back in a neutral position during pull-down, avoid lifting the upper shoulder. Make sure not to utilize momentum when pulling down the bar [2].

2.4. Euclidean Distance

Euclidean Distance is a technique of calculating distances which calculate the range of 2 points within Euclidean space. Euclid is a mathematician who introduces Euclidean Space. The equation of Euclidean Distance related to Pythagoras theorem. This equation can be applied in 3 dimensions, which are: 1, 2, and 3 sizes.

Euclidean method is proximity searching method distance value of 2 variable. Equation 1 is the equation of Euclidean Distance 2 dimension.

$$\boldsymbol{d} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \qquad (1)$$

2.5. Cosine Rule Formula.

Cosine rule equation is a rule which can explain the relation between long quadratic sides with cosine value one of the angles on the triangle. To measure the correct or false of pull-down technique is by focusing on the angle of the subject's elbow. To calculate the subject elbow in this research using cosine rule (Equation 2).

$$\boldsymbol{\beta} = acos\left(\frac{a^2+b^2-c^2}{2ab}\right) \qquad (2)$$

Figure 3 shows the illustration of the triangle made by point marker (A-Shoulder)(B-elbow)(C-wrist). This illustration then used to calculate the angle (β).

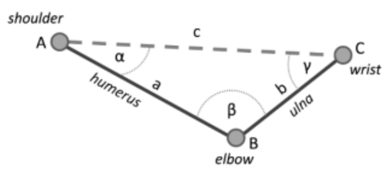

Figure 3. Example on how to calculate the angle in which the elbow is adducted.

3. Methodology

3.1. Research Methodology
Step of work which performed in this research consists of several stages, so it is structured, which can be seen in Figure 4.

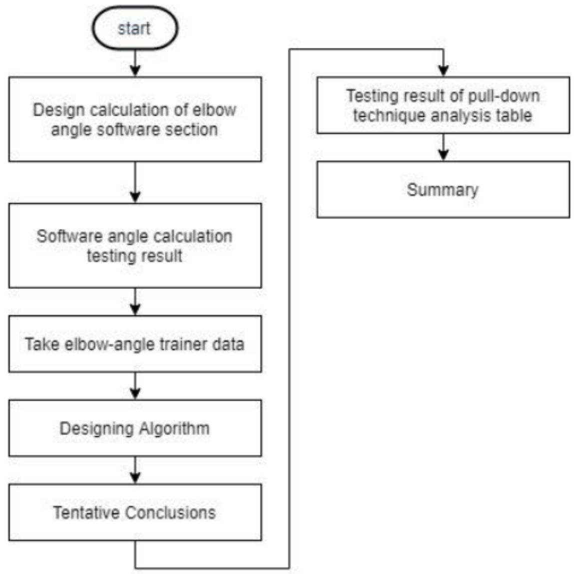

Figure 4. Research Framework

3.2. Design calculation of elbow angle software section
Calculation of elbow angle software is designed to calculate the angle of the human elbow. This is design based on a flowchart in Figure 5 and the *Pseudo code* for calculating pixel per cm also elbow angle shows in Figure 6 and Figure 7.

Images which used in this research are the result of images which taken first using a camera and then inputted to the software. At the step angle-taking Trainer, the picture which taken is when the iron bar is pulled down to reach the chin.

Before taking a picture of Trainer or Trainee is put marker first. The marker which used is 6cm x 4cm. The camera which used is Canon EOS 700D DSLR Camera using a resolution of 1920x1080 pixel. The object which used as a reference object is the Iron Cross of lat pull-down tool which is 100 Cm long. For the placement of camera which is behind the Trainee or Trainer with 320 Cm distance and using a tripod of its 66 Cm height. Camera lens Position 90° facing the subject, proved by water pass on a tripod and faced straight with Trainee or Trainer.

To measure the length of spine and resultant on image which has been taken, in this research using reference object which already known in length and reference object must be in the picture, to calculate the Pixel per Cm should be identified first long pixel reference object by giving long sign object reference, the length of pixel object reference is obtained using Euclidean distance formula. After obtained pixel length of the object, then we can calculate Pixel per Cm using equation (3).

$$\textbf{Pixel per cm} = \frac{length\,of\ Pixel\ Object}{Actual\ Length\ Object} \quad (3)$$

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Figure 5. Calculation of elbow angle software Flowchart

To get elbow-angle value in this research using cosine rule formula, based on previous research [6] [4] on the two studies, they used cosine rule formula to get the angular value of joint.

In this research required value cosine rule formula to get the angular value of elbow is the Humerus length, Ulna length and the distance length between shoulder and wrist.

```
Pseudocode for calculating pixel per cm

Declaration :

        x1, x2 ,y1 ,y2 ,x ,y , ppm ← double
        objek ← 100;
Description :

        Input (x1, y1)
        Input (x2, y2)
        x ← math.pow(x1-x2);
        y ←math.pow(y1-y2);
        d ← math.sqrt(x +y);
        ppm ← (d / objek);
       Print (ppm);
```

Figure 6. Pseudocode for calculating pixel per cm

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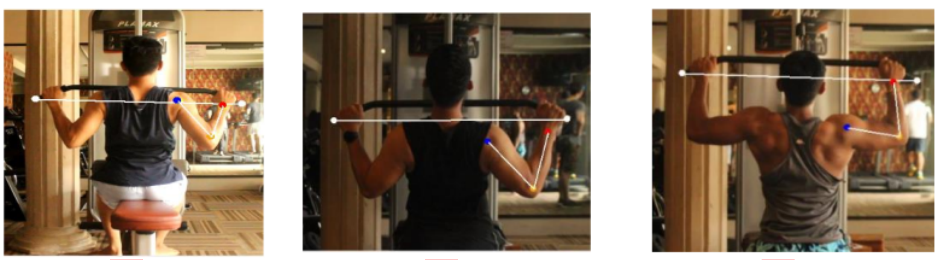
```
Pseudocode  of calculating elbow angle

Declaration:
            a, b, c, d, result, angle ←double

Descriptioni:

            Input (a, b, c);
            d ← (b * b) + (a * a) – (c *c);
            result ← d / (2 * a * b );
            angel ← Math.Acos(result) * (180 / Math.PI);
            print (angel);
```

Figure 7. Pseudocode of calculating elbow angle

To get the right angle, at this step the author will determine the standard deviation of elbow angle when the Iron Cross reach the chin, not pass through the chin (below) and pass through the chin (above) using the equation (4), based on the previous research [2] one of the correct technique pull-downs when downward movement is the iron bar reach the chin.

$$\boldsymbol{s} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}} \qquad (4)$$



(A) (B) (C)

Figure 8. The classification about the position (A). Below chin. (B). Reach chin, (C). above chin

4. Result and Analysis

At this step researcher will test calculation angle software, to know the comparison of calculated result from the software with its original object. The elbow angle in human, which used is 180 °, 90 ° and 55°. The reference object used in this test is 12 cm tape.

Spine length data, resultant length and elbow angle, which has been obtained from the software will be compared to the original to get a different value which becomes success level in software design which has been made.

Figure 9 is testing process of angle calculation software. This process called as validation. The results of this validation are showing in Table 1. The conclusion of the first experiment in Table 1 shows that the difference between the result of the software and manual measurement has 0.9^0.

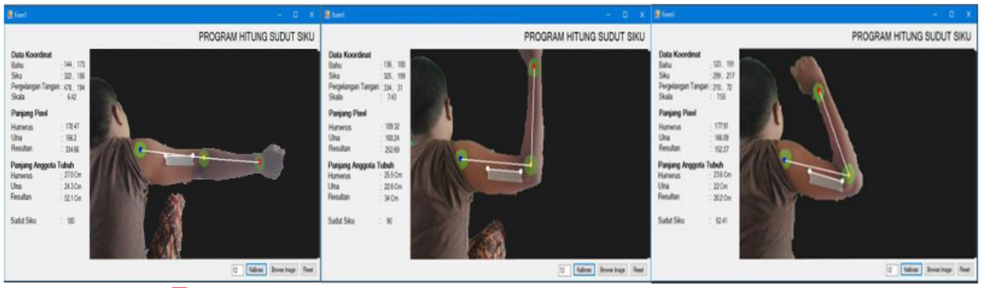


Figure 9. The experiment for validating the angle calculation result: angle 180°, angle 90°, angle 55°

Table 1. Software elbow angle calculation testing result

Testing	Elbow angle (°)			Resultant (Cm)		
	Real	Program	difference	real	Program	difference
1	180	180	0	52	52.1	0.1
2	90	90	0	36.8	34	2.8
3	55	52.41	2.6	24.1	20.2	3.9
Difference average			0.9°	Difference Average		2.3

The next step is ranging experiment of the elbow angle for three classes which are (1) below chin, (2) reach chin, and (3) above chin. This step is needed to making a range of angle prove for each of class. The experiment is conducting as much as 34 action. Each action then measure by application that has been build.

After the experiment or action has been recorded, the next step is making a statistic tabulation (Table 2). The calculation has given deviation standard value of ±7°.This result has given confirmed data due to the score of the deviation standard of each data is ±7°.The distribution data of table 2 is showing in figure 10.

Table 2. Data from trainer which taken using angle calculation software

Data No	Elbow angle	Iron (handle)
1	50°	below chin
2	50°	below chin
3	50°	below chin
4	47°	below chin
5	46°	below chin
6	46°	below chin
7	55°	Reach chin
8	55°	Reach chin
9	51°	Reach chin
10	54°	Reach chin
11	55°	Reach chin
12	53°	Reach chin

13	51°	Reach chin
14	59°	Reach chin
15	59°	Reach chin
16	58°	Reach chin
17	55°	Reach chin
18	55°	Reach chin
19	57°	Reach chin
20	59°	Reach chin
21	56°	Reach chin
22	55°	Reach chin
23	59°	Reach chin
24	59°	Reach chin
25	59°	Reach chin
26	60°	Reach chin
27	58°	Reach chin
28	59°	Reach chin
29	55°	Reach chin
30	66°	above chin
31	70°	above chin
32	66°	above chin
33	75°	above chin
34	74°	above chin

.

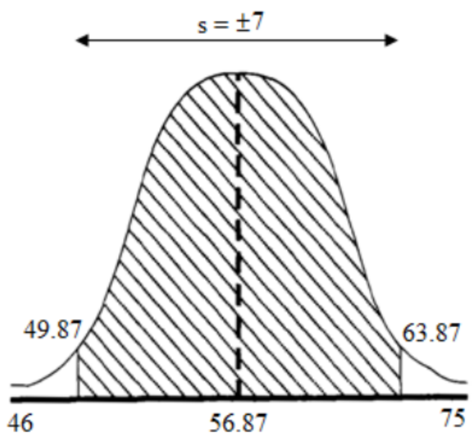


Figure 10. Distribution Normal graph *Trainer elbow angle*

From Figure 10, the conclusion can be drawn that the Correct value of elbow angle when doing pull-down, based on normal distribution graph is 56.87° ± 7°. After the range of correct angle already known, the final experiment by using the analysis program is conducted. The result of experiment is showing in Table 3.

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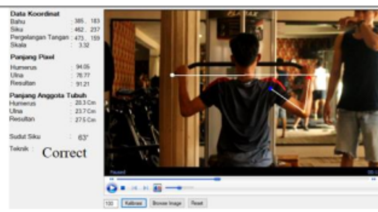
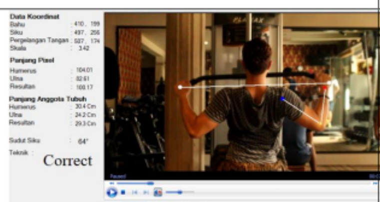
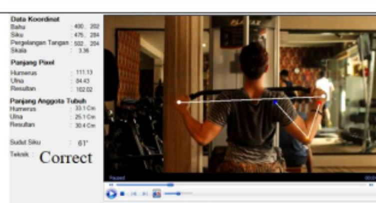
Table 3 Testing result of pull-down technique analysis table

No	Program Analysis Result	Actual Analysis
1		Incorrect
2		Incorrect
3		Correct
4		Incorrect
5		Correct
6		Incorrect

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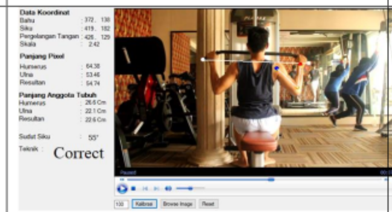
7		Incorrect
8		Correct
9		Incorrect

From 9 time test performed, 8 times program can analyse technique correctly and 1 time incorrect. The accuracy value which gained from test above is 88%. There is 12% error value, which is due to the position of Trainee's too wide when doing the downward move.

5. Conclusions

By using statistical analysis method, the correct elbow-angle data when performing lat Pull-down obtained from this research is 56.87°±7°. With accuracy, value is 88%. Hopefully, this application can be used by the trainer in fitness places to help people who are still basic in pull-down exercises to get maximum training result and minimize injury.

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