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Patent Claim Document

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PATENT CLAIM

Electronic Sit Up Station

1 Introduction

A complete sit-up exercise encompasses three distinct motions. First is the lying back position (herein called M1) where the back of the body should fully come in contact with the floorboard or platform as shown in figure 1.

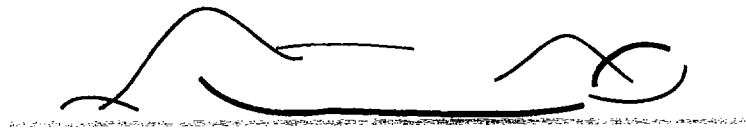


Figure 1 - showing motion 1 (M1)

Second is the upward motion (herein called M2) where the body lifts upward leaving away from the platform as shown in Figure 2.

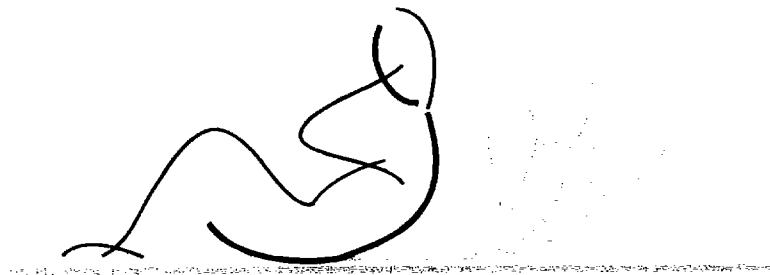


Figure 2 - showing motion 2 (M2)

Third is the forward stretching (M3), this final motion completes the sit-up cycle by touching his bended knee with his elbow.

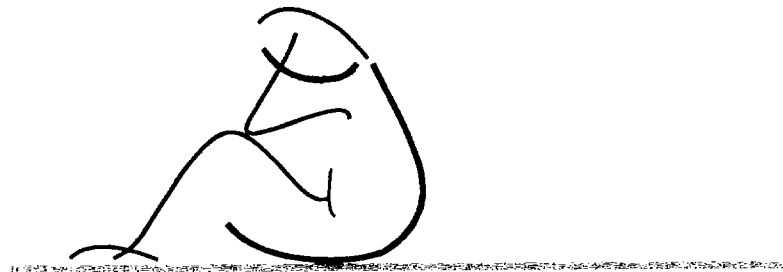


Figure 3 - showing motion 3 (M3)

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Detection Algorithm – General Description

A full sit-up cycle encompasses the complete action of M1 through M3. To detect M1_n motion, an array of optic sensors is lined-up by the side of the platform to cover the general length of the human body as shown in Figure 4. The number of sensors depends on the desired resolution. (i.e the higher the number of sensors, the higher the resolution it is and hence better precision). In addition, an ultrasonic sensor is placed at the front-end to detect M2 and M3 motion in concert with the optic sensors.

First, the algorithm automatically collects the profile (number of sensors' activation) of the body at motion zero (i.e M₀) where his body is first lie down on the platform as shown in Figure 1 (see also Fig 6). Motion M₀ is explicitly defined as the initial position taken at rest prior to his first attempt, with the back of his head touches the platform. Following the motion of M₀, the algorithm also captures the *n*th profiles of subsequent motions of PM1_{nth}, PM2_{nth} and PM3_{nth}.

Collectively the said algorithm computes the prevailing reference profiles (PR) of each motion (i.e PR_{M1}, PR_{M2}, PR_{M3}). The values of PR up to the preceding motion (M_{n-1}) are then used to set the threshold to count or validate whether the subsequent sit-up cycle (PM1_n + PM2_n + PM3_n) is successful¹

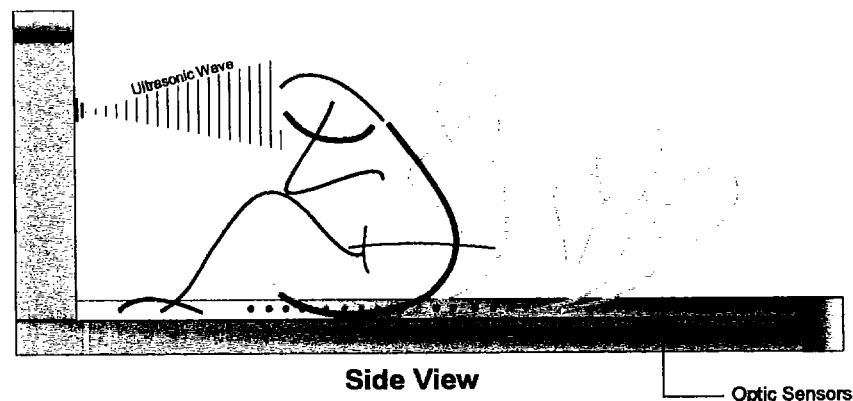


Figure 4 - showing position of optic sensor array and ultrasonic sensor

¹A successful sit-up cycle is defined as the shoulder blade must fully touches the floor at M1_n. Consecutively at M3_n the upper body should stretches forward with his elbow touching knee (bended) AND simultaneously with a valid M2_n motion where the back of the body is 'sufficiently' cleared from the platform.

2.1 M1 Detection Algorithm

For illustration purpose, say we lined-up 30 optic sensors by the side of the platform identified from S1 to S30. Different body's length will activate different number of sensors. The M1 detection algorithm simply collects the number of sensors activated at M1₀ position and takes into account that at M1₀, his head must touch the platform as shown in Figure 5.

If at M1₀ detection, the number of sensors activated comprise of S5 through S25 (a total of 21 optic sensors activated). And If each sensor is spaced at 25mm apart, then the reference profile (RP_{M1}) is set to 500 because 21 sensors has a distant of $20 \times 25\text{mm} = 500\text{ mm}$.

Strictly speaking, any subsequent n^{th} profile ($PM1_{n+1}$) that matches or greater than the value of RP_{M1} - that particular M1_n motions should be validated as 'successful'.



Figure 5 - showing head touches floor at M₀ motion

However the algorithm must take into account that it is acceptable if the head did not touch the platform at subsequent M1 motion(s) – that means the algorithm must still validate that M1_n as a successful one. Having considered that, a constant value (let call this value, discount factor dF) should be applied to RP_{M1} . This value can be used to set the stringent level (i.e Hard, Medium or Easy). Therefore the simple Count formulae for M1 can be defined as follow:

$$\text{TRUE}_{M1n} \equiv PM1_n \geq (RP_{M1} - dF_{M1})$$

where TRUE_{M1n} is set to 1 if $PM1_n$ is successfully validated

where $PM1_n$ = the profile value of M1 motion at M1_nth

where RP_{M1} = the reference profile value of M1₀

where dF_{M1} = discount factor set as $(CT/100) \times RP_{M1}$

where CT is the constant value set between 10 to 30 (typical)

In view of the dynamism of body posture during executing of M1 motion, it is necessary to allow dynamic adjustment of dF_{M1} . A dynamic correction factor (dCF) is derived by capture the prevailing average value ($PM1_{pAVG}$) up to the last preceding $M1_{n-1}$ motion.

For example, at the fifth motion of M1 where $n^{th}=5$ (i.e $M1_5$), the value of $PM1_{pAVG}$ is set to the Sum of ($PM1_0$ to $PM1_5$) divide by 6. The computed dCF_5 value is used to dynamically correct the dF constant and set the threshold for validating $PM1_{5+1}$. Hence the formula for dCF_{M1} is defined as follow:-

$$dCF_{M1} = \frac{(dF_{M1} \times PM1_{pAVG})}{RP_{M1}}$$

Where $PM1_{pAVG}$ = the prevailing average value of PM up to the last preceding M1 motion ($M1_{n-1}$).

Taking into account of the above dCF , the simple Count formulae is now revised as follow:-

$$TRUE_{M1n} \equiv PM1_n \geq (RP_{M1} - dCF_{M1})$$

Therefore the final COUNT formula of M1 detection is:-

$$TRUE_{M1n} \equiv PM1_n \geq [RP_{M1} - \frac{(dF_{M1} \times PM1_{pAVG})}{RP_{M1}}]$$

2.2 M2M3 Detection Algorithm

Prior to the initial motion (that mean at M_0), a default value is set as a starting threshold for RP_{M2} and RP_{M3} . The default value of RP_{M2} is the arithmetic mean value of $PM2$ ($M2_{MEAN}$). This mean-value can be derive from a sizeable historical population data. For illustration purpose, say $M2_{MEAN} = 75$, then the actual default value of RP_{M2} at M_0 is set to '75'

The default value of RP_{M3} is the sum of DT_{FIRST} and $M3_{MEAN}$. DT_{FIRST} is defined as the known physical distant measured between L3 and L1 (the first activated sensor nearest to L3) as shown in Fig 6. The position of L3 is physically fixed. $M3_{MEAN}$ is defined as the arithmetic mean value of $(DT_{FIRST} - DT_{MIN})$ over a sizeable historical population data.

Assuming $DT_{FIRST} = 1000$ mm and $M3_{MEAN} = 53$. Hence at $M3_0$ the actual default value of RP_{M3} is set to '1053'.

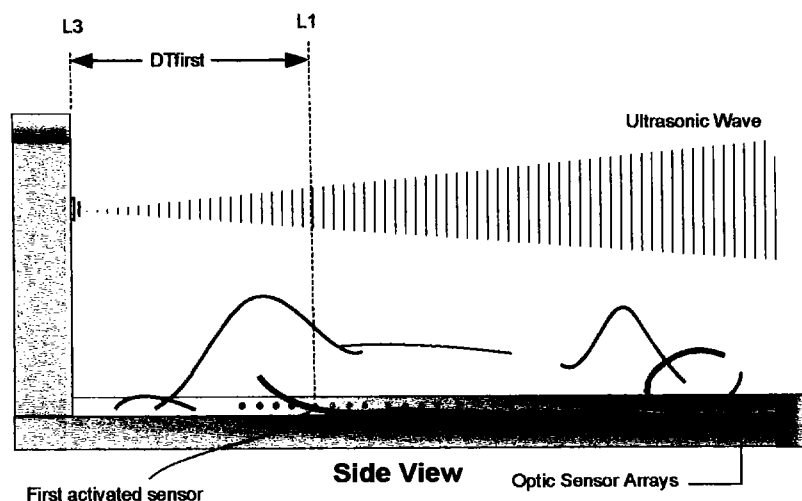


Fig 6 – showing first activated sensor at M_0

At $M2_{n+1}$, as the body lifting away from the platform the number of activated sensors will progressively decrease to a minimum value ($M2_{Min}$) - at the point where the upper body fully cleared the platform as shown in Figure 7. For example if at $M2_{Min}$, the number of sensors remained activated comprises of S5 through S8 (a total of 4 sensors activated), then the value of $PM2_{n+1}$ is set to '75' because 4 sensors has a distant of $3 \times 25\text{mm} = 75$ mm.

At the same instant, as the body lifts forward, the ultrasonic sensor progressively measures the distant (DT_{Min}) between L3 and L2 as shown in Figure 7. At the final stretch of $M3_{n+1}$ motion where his elbow touches his knee, DT_{Min} will reach a minimum value. For illustration purpose say $DT_{Min} = 1032$ mm, hence $PM3_n$ is set to '1032'.

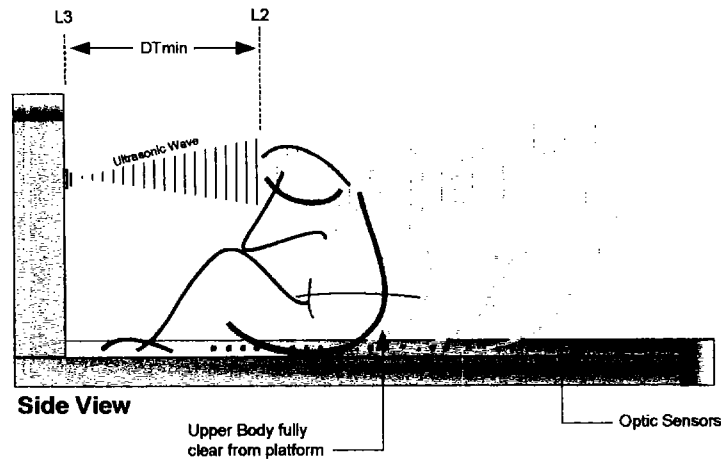


Figure 7

Strictly speaking, any value of $PM2_{n+1}$ and $PM3_{n+1}$ that matches or are lesser than the values of RP_{M2} and RP_{M3} respectively, the so attempted M2 & M3 motion should be validated as 'successful'¹.

Therefore the simple M2&M3 Count formulae is defined as follow:

$$TRUE_{M2n} \equiv PM2_n \leq RP_{M2}$$

where $TRUE_{M2n}$ is set to 1 if $PM2_n$ is successfully validated

where $PM2_n$ = the profile value of M2 motion at $M2_{nth}$

where RP_{M2} = the reference profile value at $M2_0$

AND

$$TRUE_{M3n} \equiv PM3_n \leq RP_{M3}$$

where $TRUE_{M3n}$ is set to 1 if $PM3_n$ is successfully validated

where $PM3_n$ = the profile value of M3 motion at $M3_{nth}$

where RP_{M3} = the reference profile value at $M3_0$

Similarly as in M1, a constant value of discount factor dF is introduced for user to set the stringent level (i.e Hard, Medium or Easy). Therefore the simple combined M2&M3 Count formulae can be revised as follow:

$$\text{TRUE}_{M2n/M3n} \equiv [PM2_n \leq (RP_{M2} + dF_{M2})] \text{ AND } [PM3_n \leq (RP_{M3} + dF_{M3})]$$

where dF_{M2} = discount factor set as $(CT_{M2}/100) \times RP_{M2}$

where CT_{M2} is the constant value set between 10 to 50 (typical)

where dF_{M3} = discount factor set as $(CT/100) \times RP_{M3}$

where CT_{M3} is the constant value set between 10 to 30 (typical)

In view of the dynamism of body posture during executing of M2 and M3 motions, it is necessary to allow dynamic adjustment of dF_{M2} and dF_{M3} . A dynamic correction factor (dCF) is derived by capture the prevailing average value ($M2_{pAVG}$ and $M3_{pAVG}$) up to the preceding motion of $M2_{n-1}$ and $M3_{n-1}$.

For example, at the fifth motion of M2, $n^{th}=5$ (i.e $M2_5$), the $M2_{pAVG}$ is set to the Sum of ($M2_0$ to $M2_5$) divide by 6. The updated dCF value is used to dynamically correct the dF constant and set the threshold for validating $PM2_{5+1}$. Hence the formula of dCF_{M2} is as follow:-

$$dCF_{M2} = \frac{dF_{M2} \times RP_{M2}}{M2_{pAVG}}$$

Where $M2_{pAVG}$ = value of the prevailing average up to the preceding $M2_{n-1}$ motion.

Taking into account of the above dCF , the resultant Count formulae for M2 is revised as follow:-

$$\text{TRUE}_{M2n} \equiv PM2_n \leq (RP_{M2} + dCF_{M2})$$

Correspondingly, the final Count formula for M2 is as follow:

$$\text{TRUE}_{M2n} \equiv PM2_n \leq [RP_{M2} + \frac{dF_{M2} \times RP_{M2}}{M2_{pAVG}}]$$

Similarly taking into account of the above dCF , the resultant Count formulae for M3 is also revised as follow:-

$$TRUE_{M3n} \equiv PM3_n \leq (RP_{M3} + dCF_{M3})$$

Correspondingly, the final Count formula for M3 is as follow:

$$TRUE_{M3n} \equiv PM3_n \leq [RP_{M3} + \frac{(dF_{M3} \times RP_{M3})}{M3_{pAVG}}]$$

EXAMPLE:

To successfully validate and count the 6th sit-up cycle the following VALIDATION must be true: -

$$TRUE_{M1(6)} \equiv PM1_6 \geq [RP_{M1} - \frac{(dF_{M1} \times M1_{pAVG})}{RP_{M1}}]$$

AND

$$TRUE_{M2(6)} \equiv PM2_6 \leq [RP_{M2} + \frac{(dF_{M2} \times RP_{M2})}{M2_{pAVG}}]$$

AND

$$TRUE_{M3(6)} \equiv PM3_6 \leq [RP_{M3} + \frac{(dF_{M3} \times RP_{M3})}{M3_{pAVG}}]$$

$$COUNT_{SitUp} \equiv TRUE_{M1(6)} + TRUE_{M2(6)} + TRUE_{M3(6)} = 1$$

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