JUST IMAGINE BLIND PEOPLE IN SHOOTING DRILLS. WOULD IT BE POSSIBLE?

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INTRODUCTION

It is well known that physically handicapped persons can successfully participate in many sport modalities of the Special Olympics program, where blind people compete in many sport modalities according to their classification in the classes SH1, SH2, SH3, SH4 depending on their disability. However their handicap is not compatible with the practice of precision sport modalities like shooting or archery. The endeavor of this study is to establish the theoretical frame for the development of a system that is able to generate acoustical signals in real time informing subjects about the quality of their aiming activity. In this way the practice of shooting sports by blind persons would be possible once the lacking visual information is replaced by augmented concurrent acoustical feedback (Newell et al., 1985) guiding them to move the aiming line close to the centre of the target. If this kind of guidance is workable the subjects could maintain, by training, the relative position of the body segments developing fixed and reproducible motor interactions of the joints that are controlled by the CNS.

METHODS

The main parts of the feedback loop (Fig. 1) are :

- the position and orientation of the rifle and the aiming line defined by the position that the body segments adopt under the control of the CNS
- the influence of the unknown perturbations tending to generate unbalance oscillations because of the dynamic interactions of the system parts
- the measurement system that provides information in real - time respect to the distance of the aiming point to the centre of a calibrated target
- the acoustical signal of variable intensity and frequency that is fed back to the subject by means of earphones as augmented feedback information adjusting the instantaneous current position and orientation of the rifle to the desired one
- the sources of positive feedback (+) that tend to produce unstable outputs of the system whereas the negative (-) feedback tends to stabilize system's output, at least within certain dynamic limits.

A sonic digitizing system (Engin et al., 1984) is used to convert information respect to three - dimensional coordinates of ultrasound emitters to digital values, based on the properties of sound propagation. The measurement chain consists in the SAC Sonic Digitizer (GP8-3D) that communicates with a personal computer via a parallel interface (PIO12), for higher data rate throughput, and a synchronized microphone sensor to detect the instant of triggering for shooting simulations. After the exhaustive evaluation of the sonic digitizer, according to a standarized protocol (Stüssi and Müller, 1990), its technical characteristics and performance are resumed to :

- number of markers : 16 sequentially activated (time multiplexing) ultrasound emitters that are automatically identified
- active volume (V) : 1800mm x1300mm x1400mm
- range of measurement (D): 2625 mm
- nominal systems resolution (r): 0.1 mm
- definition of the system (d): 16 bits
- accuracy (A): 0.054 with $A_x = 0.022$, $A_y = 0.038$ y $A_z = 0.032$
- precision (P_i) of the measurement of the distance to the microphones : P_A=1:23893, P_B=1:26300, P_C=1:28564, P_D=1:27967
- precision (p) of the reconstructed 3-D coordinates of the emitters: 0.115 mm with p_x=1:28125, p_y=1:26000, p_z=1:17073
- sampling rate of the whole system (f): 66.6 Hz
- sampling frequency per emitter (f_e): 22.2 Hz.
- spatio -temporal resolution of the system (Q): 70.7 $\sqrt{Hz}\ mm^{-1}$.
- Maximum time of data acquisition: 30 sec
- calibration time: 5 minutes

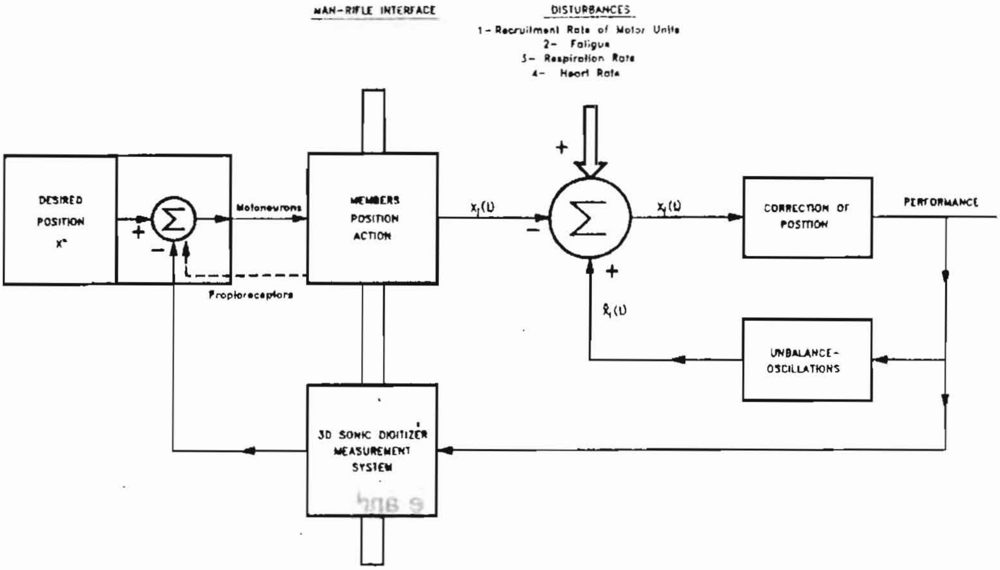

Figure 1. Conceptual representation of the information flow in the feedback loop.

The algorithm for the calculation of the distance of the aiming line to the centre of the target consists in the next steps :

- calibrate the centre of the target
- define an orthogonal local system of reference (S_l) associated to the rifle by means of three ultrasound emitters fixed on it where one of the markers is selected as the origin
- determine the aiming line in the (S_l) as the vector defined by the tip of the rifle and the centre of the target.

If the positions of the three emitters are continuously tracking the kinematics of the moving rifle with respect to the global system of reference (S_g) is fully defined. Also the direction of the aiming line respect to the local system of reference can be monitored (rifle calibration). This implies that it is possible to determine the variation of the aiming line respect to the global system of reference by means of matrix transformations operations of the type

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{S_g} = \mathbf{A} \begin{bmatrix} x' \\ y' \\ z' \end{bmatrix}_{S_l}$$

Next step is to calculate the distance of the intersection of the aiming line with the plane of the target to the centre of the target. Knowing that distance the personal computer produces a signal that is transformed to an acoustical signal of variable intensity and frequency to inform subject via earphones about the proximity to the target.

CONCLUSION

This study makes clear that it is possible, at least theoretically, to develop a loop of feedback information about the position and orientation of the rifle to the target, guiding blind persons to adjust continuously the aiming line respect to the centre of the target and press the trigger at the right instant. Besides, it is possible to simulate shooting for training.

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