INSTRUMENTED HARNESS TO IMPROVE THE WELFARE OF GUIDE DOGS

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Introduction

Common assistive technologies for the visually impaired people (VIP) include white canes, electronic mobility aids and guide dogs. These aids enable VIP to navigate and detect obstacles in their path. The most commonly used tool is the white cane, but it has its limitations in detecting distant or moving objects as well as obstacles detached from the ground surface. To improve the perception of the environment and avoid objects, several assistive systems have been proposed [1]. These devices inform the VIP about hindrances and provide audible or tactile feedback. Although these aids offer some assistance, users must still navigate around obstacles themselves. Guide dogs, on the other hand, can detect objects from a distance and help VIP navigate around them. However, training guide dogs is time-consuming and expensive. Therefore, efforts are made to extend the working life of these dogs.

During the guidance, the VIP is connected to his dog companion via a harness and a handle. This handle links to the abdominal belt of the harness via two support points positioned approximately on the left and right side of the dog's shoulder. An angle is created between the two support points when the handle is moved from its neutral position. Due to this introduced torsion and the tight linkage in the harness, excessive and permanent displacement of the handle can cause strains on the musculoskeletal system of dogs and thus lead to kinematic changes in their gait behaviour [2]. Hence, recent research suggests improving harness designs to reduce their impact on the dog's biomechanics [3, 4].

In this context, we developed an instrumented guide dog harness. Our device is equipped with a millimeter wave radar technology which detects angular changes of the harness and returns biofeedback over an audio signal. We tested our system under laboratory conditions and demonstrated a measurement accuracy of our algorithm of 0.735° ± 1.877°.

Methods

System: Our portable prototype (Figure 1a) consists of a mm-wave radar (A111, Acconeer AB, Sweden) controlled by an RPi 4B (Raspberry Pi, UK) and powered by two Li-Ion batteries. Radar and controls are mounted to the bar near the grab handle. Two corner reflectors attached to the support points at about the height of the dog's withers provide information about the prevailing geometry and the angle of handle position. The radar operates at 60 GHz and evaluates the energy in the reflected echoes from multiple transmitted pulses.

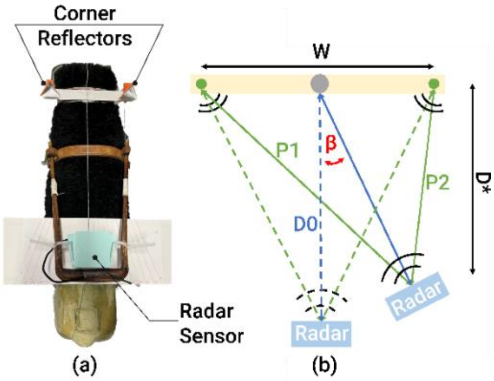

Figure 1: (a) shows the mounting of the setup on the dog harness. (b) depicts the geometry of the harness during angular deviation (P1 and P2 – distance between radar and reflectors, D0 neutral distance, D – actual distance, W – width of reflectors)*

Algorithm: When the harness deviates from its neutral position (resulting in differing distances between the radar and its left and right reflectors, as depicted in Figure 1b), two peaks appear in the amplitude-time-delay curve of the reflected echoes. The amplitude-time-delay curves are smoothed using a Savitzky-Golay filter, and the angle (β) of the harness handle is calculated from the analysis of the resulting peaks using the cosine theorem (Equation 1).

$$\beta = 90 - \cos^{-1}\left(\frac{D0^2+\frac{W^2}{4}-P2^2}{W \cdot D0}\right) \qquad (1)$$

Biofeedback: Our system allows biofeedback via a tone (750 Hz) with increasing pulse frequency at increasing angular deflection.

Validation: To test the accuracy of our system and ensure repeatability, we used a table prototype that mimics the movement of the harness. A motor with a rotation speed of 2° per second was used to rotate the two corner reflectors while the radar acquired data from the reflectors. The actual angle (controlled via the motor) was compared with the measured angle (captured with the radar).

Results and Discussion

Our system detected angular positions with an accuracy of 0.735° ± 1.877°. Hence, our prototype confirms the applicability of radar technology for the use in guide dog harnesses and provides the first biofeedback system solution for guide dog education.

References

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