

DISCRETE TARGET DETECTION: AN INNOVATIVE APPROACH

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Abstract – In this paper some remarks about an innovative sensor for discrete distance measurement developed by the authors are discussed. The purpose of the proposed sensor is the measurement of remote target position independently on the property of the reflective surface. Application in the field of visually impaired people is in the large context getting serious advantage by the use of such apparatus.

The possibility to obtain a low cost sensor device assuring the required performances is investigated. Non-linear post-processing of the signals given by the sensor has been implemented improving the quality of the gathered information. Main features of the proposed system are its insensitivity to the target material and also to the influence parameters (e.g. light condition), high flexibility and reliability.

Keywords: Distance measurement, smart signal processing, high performances device.

1. INTRODUCTION

Usually contact-less sensing devices for position measurement are hardly dependent on both reflective properties of the target surface and brightness of the working area. These drawbacks have a significant impact on the sensor behaviour especially in the case of extremely varying operating condition. Actually, suitable results would be obtained by using either high performing devices or complex systems resulting in high cost features and very hard characterization process. These two characteristics are extremely in contrast with general-purpose application requiring low cost and easy to use features in spite of the optimization of other characteristics such as the system resolution.

In this paper some new results concerning the sensing device for discrete distance measurement, already announced by the authors in the past, are discussed [1]. The device is intended to smooth the above-mentioned drawbacks by gaining a suitable performance to cost ratio.

It should be reminded that the device is aimed to detect remote objects independently to both their nature and environmental condition for the autonomous navigation of visually impaired people in domestic areas.

Low cost feature, along with system flexibility and reliability are hence required. As will be detailed in the following, the working range of the device will be divided in

a number of zone (called distance ranges). The information given by the system concerns the position of the target in terms of the distance range where the target is located. As a consequence, a reduced resolution will be obtained.

In the following some notes on sensor structure will be reported for sake of convenience.

2. AN OVERVIEW OF THE SENSING DEVICE

A sketch of the developed sensing device is reported in Fig. 1. The proposed device is made by two sensor arrays (the emitting array and the receiving array) performing the required measurement. The codification of the target distance is obtained by combining the information given by the sensor network operating in threshold mode.

In order to describe the main idea on which the device is based a number of concepts must be stressed: the path followed by the ray spot, the relationship between the target position and the system response are of quite interest.

Each receiver processes signals coming from the emitter after target reflection. From a theoretical point of view, each receiver could collect signals coming from any transmitter, as sketched in Fig. 1 and (in the case of fine spot) the signal generated by one of the emitters should be detected by one of the three receivers. On the target position will depend which one of the emitted signals will be reflected and which receiver will detect it.

Circles in the figure represent the target position allowing the reflected signal to follow the right path to one of the receivers. Theoretically, only information on punctual position is available.

In real case things appear quite different and the above consideration must be revisited. Tolerance coming from both the target reflection angle and the sensor emission corner will introduce gaps (distance ranges) instead of punctual location, which identifies the target position. Actually, the information on the discrete position of the target is extended to information on a distance range, due to the emission corner of each sensor. Moreover, due to the same fact the presence of one obstacle can cause one of the reflected signals to be detected by two or more receivers. This will increase the quantity of information about distance codification given by the system in spite of a more complicate decodification procedure.

It should be underlined that the receiver stages operate in threshold mode allowing knowing if the target belong to a certain ranges or not.

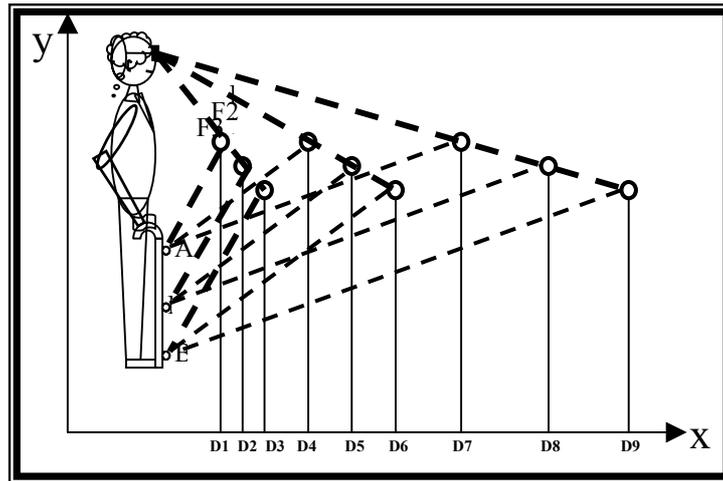


Fig. 1. A representation of the sensing device for target detection.

This strategy should be quite insensitive to the value of the received signal amplitude that is strictly connected to the target material and the environmental condition. This way to codify the distance perfectly fits with the aim of the developed device, because the reliability of the system response is much more important than its resolution, due to the extreme task to be absolved by using the considered device.

The adopted sensors are general-purpose coupled IR emitter/detector devices characterised by low cost feature, contact-less operation mode and small dimension of the ray spot giving suitable performances to the whole system.

The position (height) for both the transmitters and the receivers have to be fixed on the basis of the developed application. Modification in these values will lead to a new definition in the sensor inclination and post-processing procedure, but will not affect the performance of the device.

On the basis of the last considerations, high performance and great flexibility are required of the post-processing stage, assuring the possibility to implement complex computational paradigm for signal elaboration and suitable arrangement in sensor topology, respectively.

2.1. The signal processing stage

The conditioning components of the considered system giving suitable performance are described in this section.

A schematic representation of the driving and conditioning blocks is reported in Fig. 2. As it is sketched, in order to drive the IR emitter devices, three astable circuits have been used (oscillating at three different frequencies f_i , $i=1..3$), each one followed by a current buffer. Of course, in order to properly process the information at the receivers, the emitted signals must be different. In particular, in the proposed case the three infrared devices emitting the three signals with different frequencies are placed with known inclination. Indeed, three PLL's for each receiving device allow detecting which one of the three emitted signals is reflected on the considered receiver.

The adopted IR emitter is a suitable photo-diode, allowing detecting the target up to 200 cm [2].

The task to be accomplished by the smart unit is the adequate processing of signals given by the PLL's stage.

These signals must be properly elaborated in order to redirect the output of the whole system with a time consuming compatible with the performance required by the application.

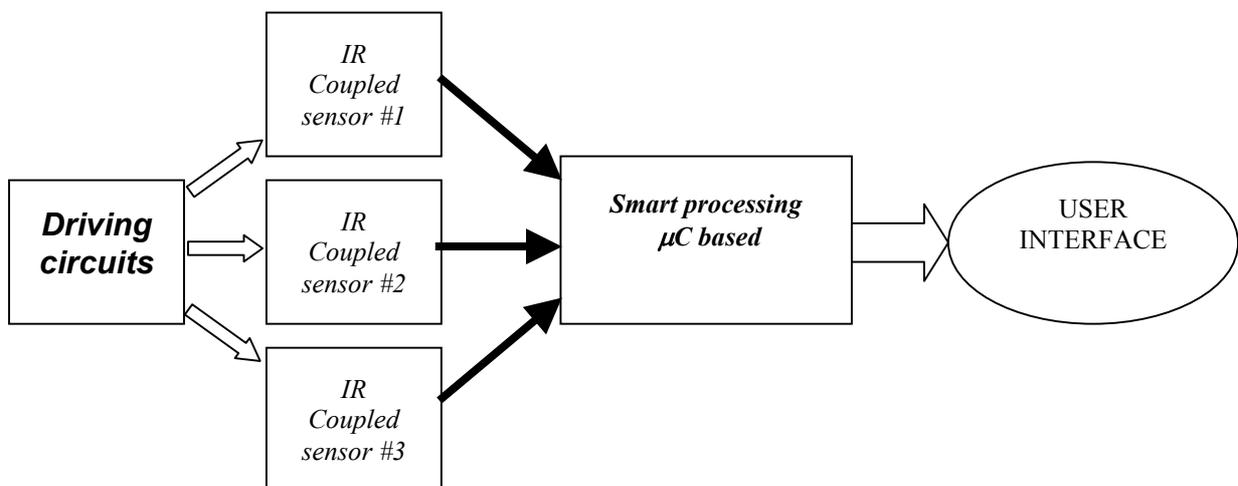


Fig.2. The conditioning blocks (from left to right): the emitting diode; the smart processing stage; the user interface.

On the basis of these features a hardware processing stage would behave better than software one. In previous work authors discussed another run of a similar device with a software post processing stage. In particular, the smart processing unit was implemented in LabVIEW®, a development tool for virtual instrument by National Instruments. At that time the choice of using a software tool for signal processing was due to the suitability of this solution especially during the optimisation and designing phase, requiring a high flexibility and ease of re-setting the system parameters. For what regards the processing strategy for the manipulation of data gathered by output sensor array combinatory logic net was implemented, based on a number of crisp rules. Due to the interaction between the detected signals, the proposed sensing device is able to detect distances as far as 240 cm with a 60 cm step and the necessity of using more efficient processing strategy arises.

At present, a hardware post-processing stage is used being the one illustrated in Fig.3 just the conditioning circuitry for one receiving device.

A micro-controller based signal elaboration has been used to process signals given by the conditioning circuits in order to join time consuming constraint with the need of smart processing. The adopted micro-controller is the ST-52430 device by ST Microelectronics, including a fuzzy core. This device performs very well non-linear task in spite of common features of other programmable micro-controllers. The choice of using this particular device arises from the necessity of performing a quite strong non-linear processing of the acquired signals, assuming this task a hard priority compared to the possibility of implementing a large amount of standard instruction. As first, the experimental set-up reported in Fig. 4 has been implemented and several measurements have been run to investigate the

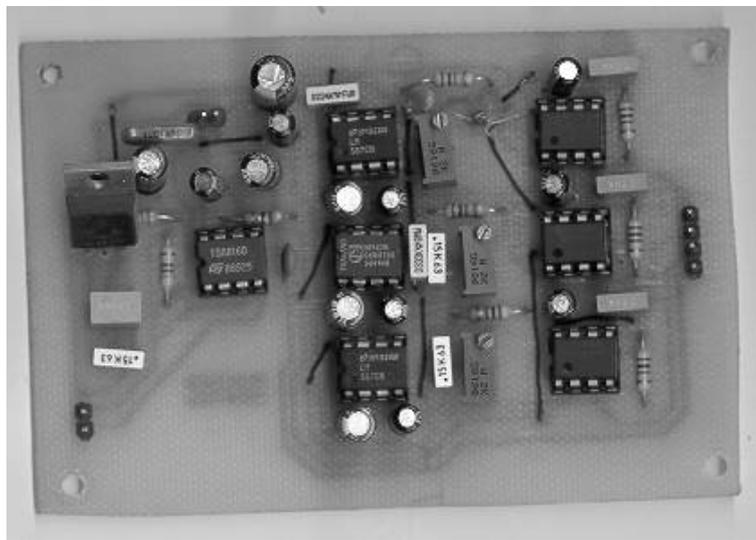


Fig.3. The conditioning circuitry used to process signals coming from one of the receiver devices.

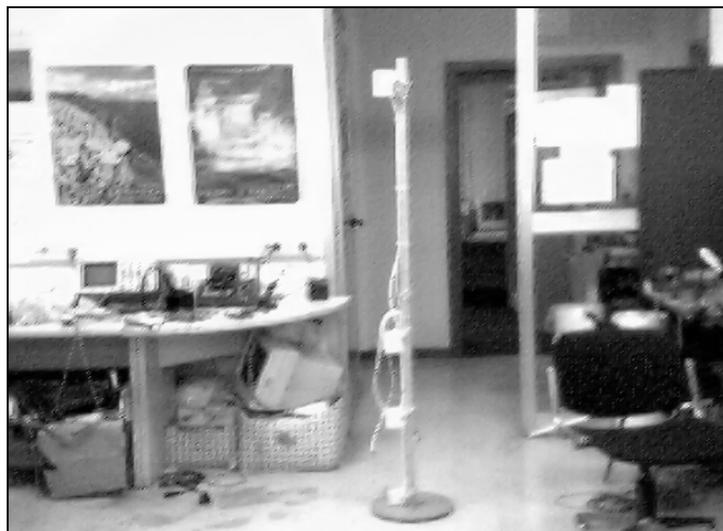


Fig.4. Experimental set-up of the remote sensing device for target free position measurement.

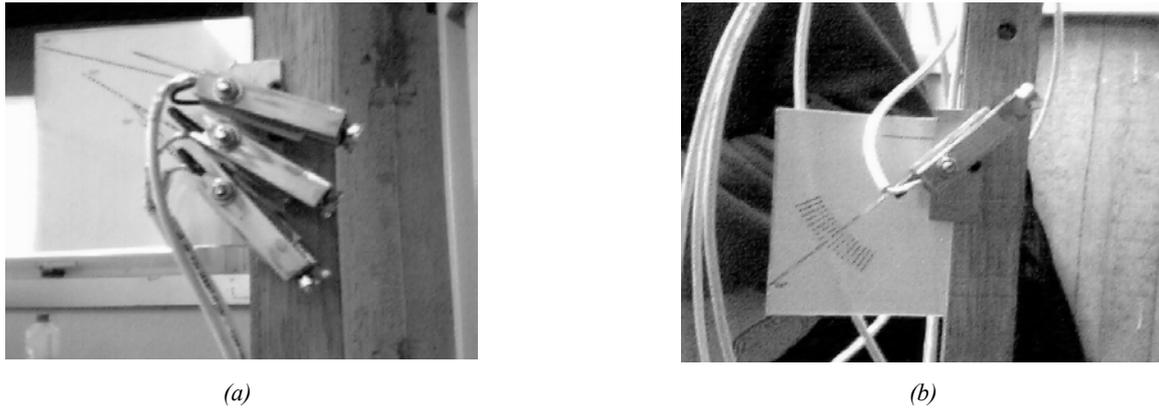


Fig.5. The emitting (a) and the receiving (b) sensing devices.

system behaviour. Figures 5a and 5b zoom on the emitting and receiving arrays respectively.

In order to perform the device characterization and to collect a representative data set a dedicated tool has been developed. The LabVIEW environment has been chosen due to its flexibility in developing performing user interface. Full automatic software performing the system characterization has been implemented. Communication between the PC and the sensing devices has been supported by means of the RS-232 protocol managed by the ST-52430 micro-controller, as schematized in Fig. 6. By using the developed instrument signals collected by the receiver array

in extremely varying working condition has been acquired to be suitably processed.

Compared to the previous work adaptive non-linear algorithm are under investigation. In particular, fuzzy models allowing for a smart manipulation of acquired data have been addressed. Fuzzy model structure (membership functions and fuzzy rules) seems to promise good performances for the developed system due to the complex relationship emerging by a correlation analysis between data acquired from the system outputs. Moreover, a deep characterization process would be required to improve the performance of the developed system in terms of resolution.

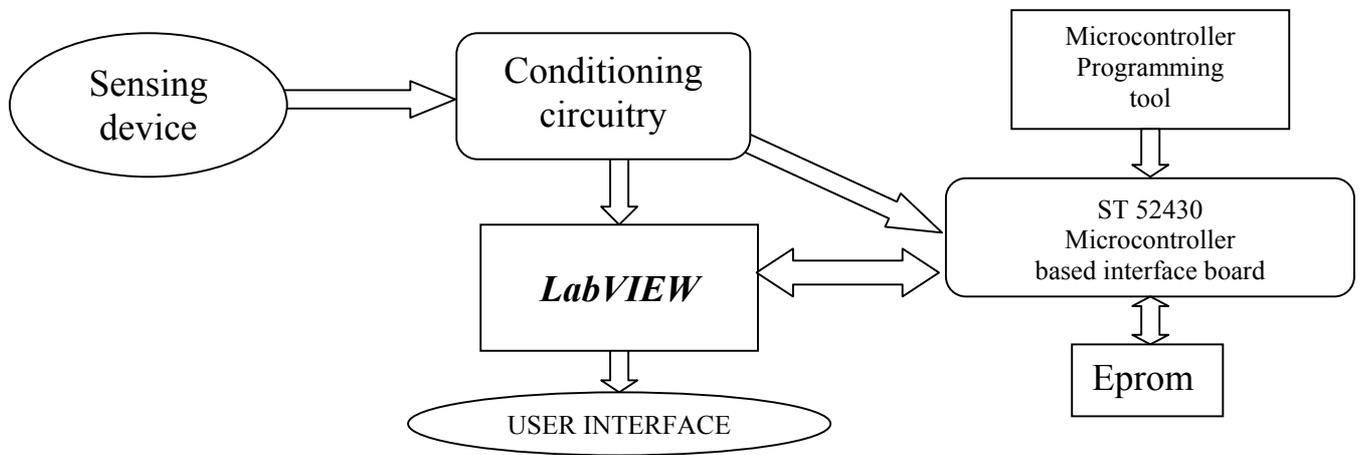


Fig.6. The characterization tool developed by using LabVIEW software and RS-232 communication protocol.

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