A SMART SENSING METHOD FOR DISCRETE DISPLACEMENT MEASUREMENT

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Abstract - *In this paper a new displacement sensing device, based on both a new sensor topology and a smart signal processing is discussed. The main feature of the proposed system is its insensitivity to both the target material and the influence parameters (e.g. light condition). As an example, the sensor can be minded as a useful tool for visual impaired people, to help their navigation in unknown place, being (for this purpose) the material-free feature much more important than the resolution. Moreover, the developed device has the advantage to be a low cost system.*

Keywords – Distance measurement, target free operation, smart signal processing.

1. AN OVERVIEW OF THE SENSING DEVICE

The aim of the proposed sensing device is to detect the presence of remote objects independently to both their nature and environmental condition. The device is composed by two main parts: the first part is dedicated to signal transmission while the second part allows to process the received signals. The working principle of the proposed system is shown in Fig.1.

To fix the target the information related to the distance cannot be obtained by processing the amplitude of the reflected signals. Infact, the signal level is strictly correlated to the target material [1]. A different codification of the target distance information is hence proposed.

The distance codification is obtained by combining the information given by a sensor network operating in threshold mode. This means that each sensing system is employed to know if the obstacle is belonging to a defined distance range. For what concerns the characteristic of the adopted device, *IR* sensors have been used. This choice was supported by the following required features: low cost devices, contact-less operation mode, small dimension of the ray spot to be driven to both the target and the receiver assuring a suitable resolution of the whole system.

In order to focus the main idea the device is based on, in Fig.2 a schematic representation of the system is reported.

The signal generated by one of the emitters is detected by one of the three receivers depending on the target position. Of course, in order to properly process the information at the receivers, the emitted signals must be different. In particular in the proposed case three signals with different frequency are emitted by three infrared (IR) devices, placed with known inclination.
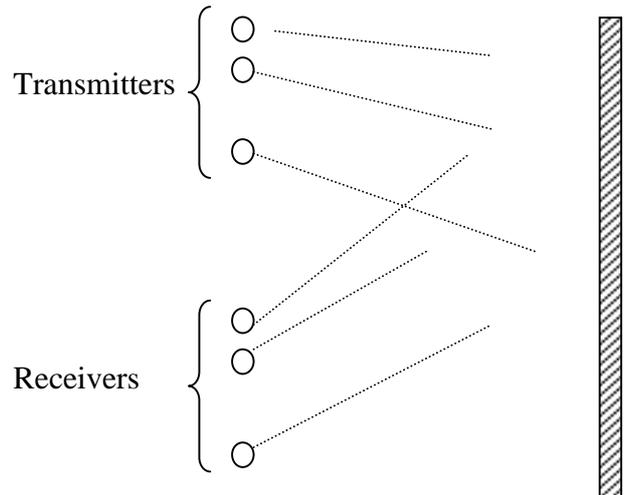

Fig.1. The schematisation of the developed sensing network.

The transmitting transducers are placed to a height of about 170 cm, while the receiving transducers are placed at three different heights (e.g. on a stick to be kept in vertical position), as shown in Fig.2.

Of course the position (height) for both the transmitters and the receivers have been fixed to standard values. Modification in these values will lead to a new definition in the sensor inclination, but will not affect the performance of the device.

As can be observed, accurate information on the target position can be obtained with a few number of devices, by suitably processing the signals detected by the receivers. For example, from a theoretical point of view, each target in Fig.2 can be univocally detected on the basis of the receivers response combination. This way to codify the distance perfectly fits with the aim of the developed device, being the reliability of the sensor output much more important than its resolution.

It should be observed that the information on the discrete position of the target can be easily extended to an information on a distance range, due to the emission corner of each sensor.

Moreover, due to the emission corner, the presence of a obstacle can cause a reflected signal to be detected by two receivers. This will lead to a more complicate decodification procedure as will be discussed in section 2.

For the presented case, the sensing device configuration has been chosen in order to improve the system resolution in the extreme low region of the working range.
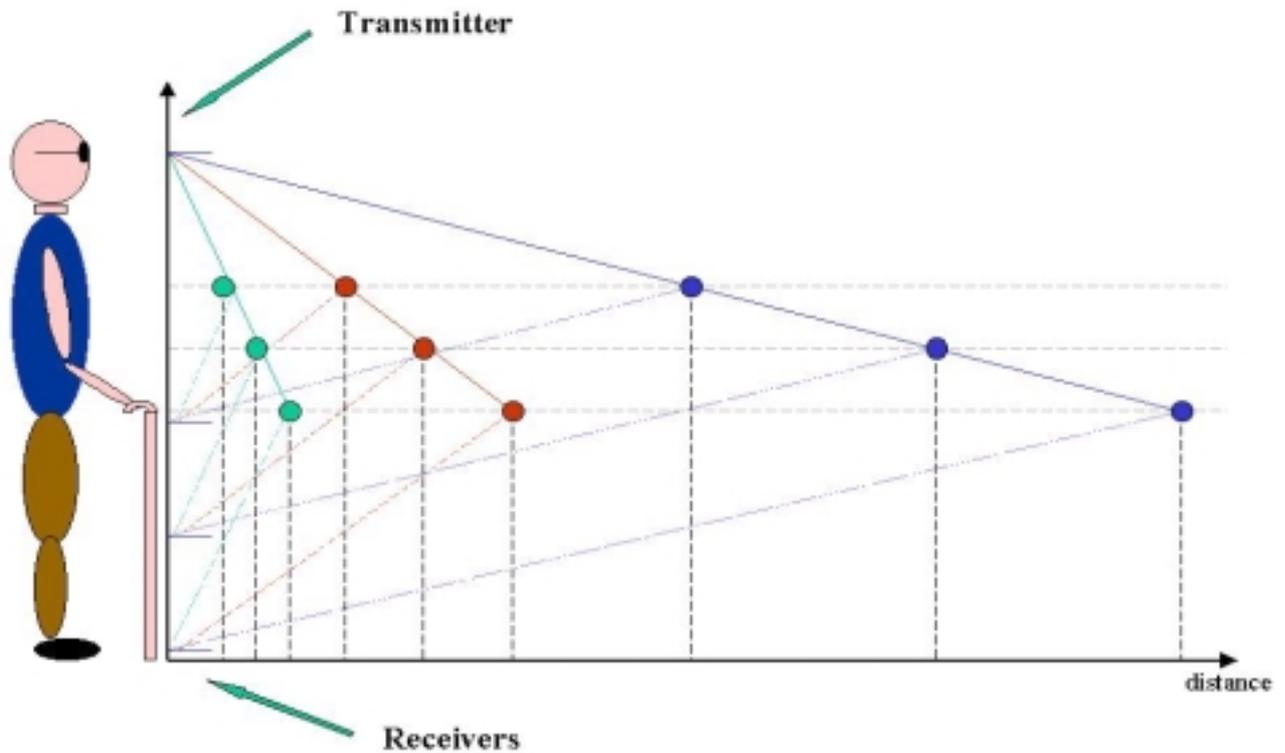
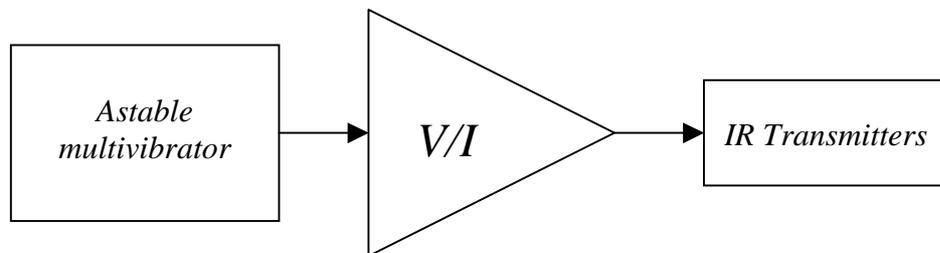Fig.2. The theoretical map for the transmitted and reflected signals.

Fig.3. The emission scheme. Blocks (from left to right): an astable multivibrator; a voltage to current converter; the emitting device.

2. THE CONDITIONING CIRCUITS

In this section, a conditioning topology for the considered device, giving suitable performance, is described.

In order to drive the IR emitter devices, three astable circuits (oscillating at three different frequencies f_i, $i=1..3$) each one followed by a current buffer have bee used.

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

The conditioning system for each receiver (three in the described topology) consists of the blocks reported in Fig. 4.

The first stage consists of an IR receiver device carefully chosen to avoid the influence of environmental parameters (e.g. light, temperature).

To detect the emitted signals three selective amplifiers are required. To bypass the filtering problem, PLL circuits (phase locked loop) have been adopted, each one giving a logical output signal when a fixed frequency is present on its input gate.

In particular, three PLL's for each receiving device allow to detect which of the three emitted signals is reflected on the considered receiver.

The last stage, dedicated to the elaboration of the logic signals given by the PLL represents the smart unit of the proposed device. Either a software or an hardware implementation of the smart unit can be realised, being the first one suitable during the optimisation and designing phase.
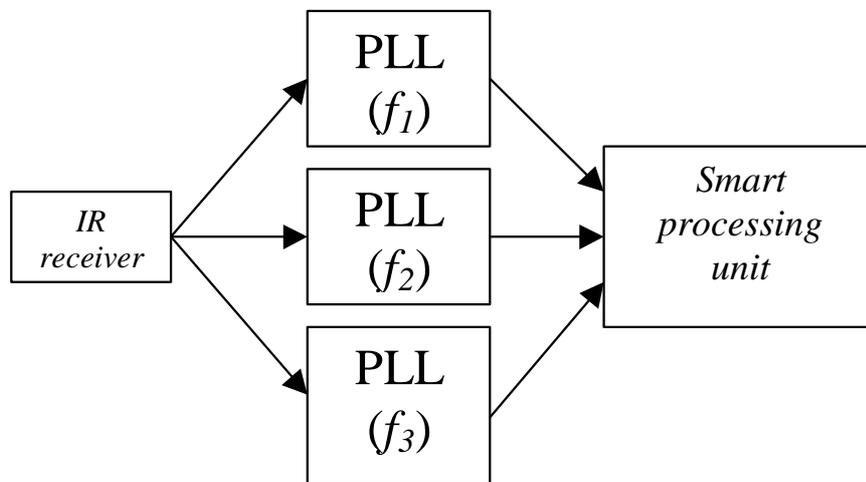

Fig.4. The receiver scheme. Blocks (from left to right): the emitting diode; a PLL; a low pass filter.
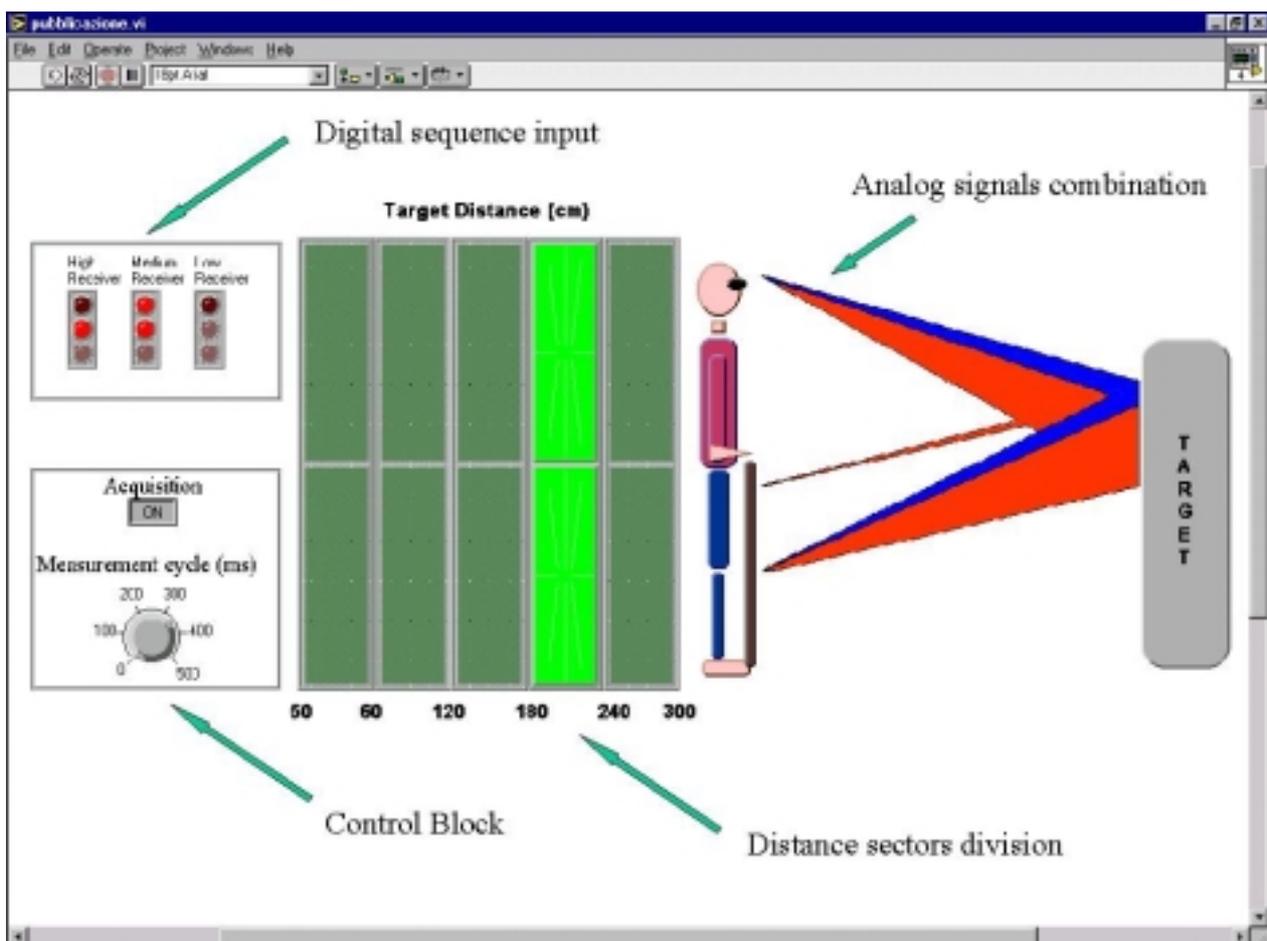

Fig.5. The front panel of the virtual instrument implementing the smart unit of the sensing device.

3. THE EXPERIMENTAL SET UP

In order to test the performance of the proposed device an experimental set-up has been implemented. In particular, the smart processing unit has been implemented in LabVIEW®, a development tool for virtual instrument by National Instruments.

A combinatory logic net has been implemented to process the logic signals.

The front panel of the developed instrument is reported in Fig. 5; it represents a possible case of signal combination.

Several measures have been run in order to characterise the system behaviour.

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. The possibility to develop new signal processing tool using non linear algorithm (such us fuzzy logic) and analog microcontroller is under consideration.

REFERENCES

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