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General List of Topics

Technology of Remote Recognition the Dart-Arrow on the Target

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***Abstract* – In the work is proposed the technology of remote recognition of the image of the dart on the target. Proposed technology based on the IR sensor frame and realized as an external module.**

Keywords – hit recognition, dart, target, hit detection, IR, sensor system.

I. INTRODUCTION

The problem of pattern recognition occurs in various spheres of life and needs research, taking into account the peculiarities of the nature of the recognizable image [1,3]. Often, there is a need to recognize the position of certain objects in relation to other objects. Especially often this problem arises when conducting various sporting events to determine the exact place of entry to the target or the playing field. Object recognition can be realized in many ways [5]. Some methods include mounting tracking devices in the object itself.In some cases, it is necessary to solve the task of tracking the position of an object without interfering with its design, as it may lead to deterioration of characteristics or decrease in the quality of the tracked object [4]. In the given article is considered the problem of recognition of the image of the dart on the target . The design features of the dart and the target have affected the proposed technology.

II. CHARACTERISTICS OF THE TARGET AND THE ARROWS

For a modern darts game, the targets are usually made of sisal (compressed fibers of agave). In Asia, common targets are made of horse hair. The idea of using sisal for the production of targets is owned by Nodor, and the first sisal targets appeared in 1932. The sections of the typical sisal target are separated from each other by a wire. The target is divided into sectors that are assigned numbers from 1 to 20 (Fig. 1) [2].

Sisal targets differ by the form of separation wire [2]:

- Normal (round) wire is characterized by a large percentage of dart (arrow) rebound (when arrow hit into a wire) and a low price. Used in the target of such manufacturers as: Winmau Pro SFB, Nodor Supabull II, Harrows Club.
- The triangular wire is characterized by a reduced percentage of wire rebound. When you hit the wire, the dart "go" along the border to the nearest sector. It is used in the target of such manufacturers as: Nodor Supawire, Harrows Apex Wire, Winmau Diamond.

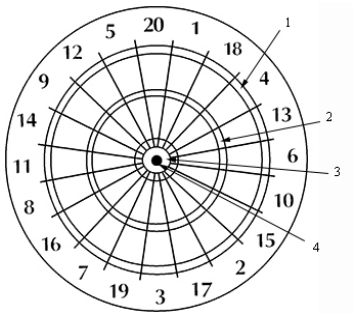

Fig. 1. Schematic view of the target with sectors (1 – "double ring", 2 – "triple ring", 3 – "Bull", 4 – "Bull eye").

- Thin split wire is used for professional purposes. Such a wire is characterized by a smaller number of dart rebounds and a high price. It is used in the target of such manufacturers as: Winmau Blade 5 Dual Core, Winmau Blade 5, Unicorn Eclipse Pro, Harrows Matrix, Nodor Supamatch II.

Standard target sizes:

- inner width of rings "double ring" and "triple ring" 8 mm.
- inner diameter of "bull's eye" 12.7 mm.
- inner diameter of the outer center ring "bull" 31.8 mm.
- the distance from the center of the target to the outer side of the "double ring" ring is 170.0 mm.
- distance from the center of the target to the outside of the wire of the ring "triple ring" 107.0 mm.
- the total diameter of the target is 451.0 mm ± 10.0 mm.
- thickness of wire is 1.5 mm.

Dart – a special arrow for playing darts. The main parts of the dart (Fig. 2) are the tip, barrel, shank and plumage [1].

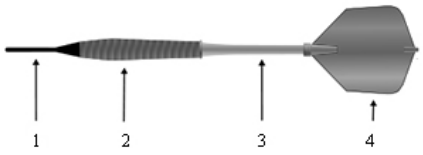

Fig. 2. Components of the dart (schematic view): 1 – tip, 2 – barrel, 3 – shank, 4 – plumage.

The dart's tip can be made in the form of a sharpened metal needle, which is designed to be stuck in the target. Also, the tip may be as a plastic needle (suitable for playing in electronic darts). The dart tip is firmly fixed in the barrel. On the other hand, the barrel includes a shank with plumage. The material and shape of the barrel determine the flight path of the dart, it is made of various metals: brass (massive cheap dart models), silver-nickel alloy (models of the middle price category), tungsten (expensive professional models).

The length of the dart should not exceed 30.5 cm. The weight of the dart should not exceed 50 grams. The most popular weight of darts is 19-25 gr.

The design dimensions of the target and the dart allow to consider several variants of placement of sensors for realization of the image recognition system (to determine dart position in the target).

III. Automatic Registration of the Dart Hit in Target - a Review of Possible Systems

A. *"Electronic Darts" System*

Classic darts are the most common and preferred: durable, especially if made by leading manufacturers. The playing field consists of compressed sisal fibers that are glued to the support board. Darts have a standard pointed tip that pierces the hole in the material.

In electronic darts, in contrast to the traditional darts, the construction is made of plastic lining and has a number of holes through which are able to pass special soft dart tips (Fig. 3). An electronic board is located under the playing field. Each time the tip of the arrow hits the board, the account is digitally registered on the board.

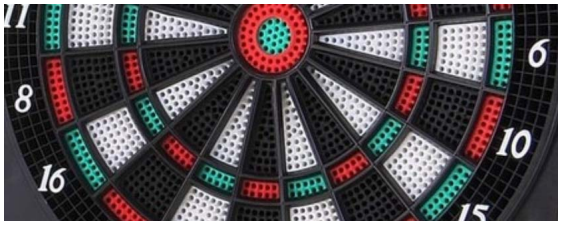

Fig. 3. Example of an electronic darts target with multiple holes (enlarged image)

Electronic darts are suitable for novice players, since the holes in the target are large, which helps to easily hit the target. Electronic darts are entertaining and not widely used for professional competitions. Using darts with a plastic tip reduces the choice of possible options for darts [2]

B. *Installation of the registration system in the basis of the sisal target*

It is theoretically possible to install sensors for automatic registration of the dart hit in the base of the dart target . These sensors can record the hit of the dart in the target based on pressure or other signs. The disadvantage of this approach is the short-lived gaming field of the target, which is due to the material of its manufacture.

The material from which the target is made (sisal or horse hair) gets damaged from the hit of dartes under intense exploitation. This necessitates the periodic replacement of the target board.

With the intense use of the game field (targets), there is a need for frequent replacement of the target. When mounting a hit registration system at the target, the cost of making the game field will be increased. It is economically unprofitable to make a new registration system for hit and fit it into a target at each change of target.

C. *Installation of the registration system in the dart arrow*

Another approach to registering a dart in the target is to mount the sensor to the dart. Dart – strictly individual inventory.

Given the diversity of the range of dart arrows, there are several drawbacks in installing a fixing system in the dart. These disadvantages are critical for the use of such a system of fixation in professional sports.

Such disadvantages are:

- Increase in the mass of the dart arrow due to the additional mass of the built-in sensor;
- Possible deterioration of dart aerodynamic properties due to deflection of the center of gravity;
- Restricting the ability of players to select darts. Some professional players prefer dart arrows of a certain weight or a certain brand. Installation of the registration system in the dart prevents the use of "favorite sports equipment" and makes use of only the "sensors" darts.

IV. External Module for Detecting the Hit of a Dart in the Target Based on the Infrared Sensor Frame

The disadvantages of implementing a system for detecting hits in the body of the target and in the body of the dart make it impossible to implement the previously considered variants for the recognition of hits. To use sisal targets and various darts it is proposed to use an external module to fix the hit.

One possible solution to the problem may be the installation of a sensor frame around the target. The shape of the sensors frame is rectangular (square) with a side of at least 451.0 mm ± 10.0 mm (preferably larger because of the theoretical possibility of hit outside the target).

The operating principle of the proposed sensor system for detecting hits in the target is based on the optical (infrared) touch screen (infrared grid).

A. *Infrared Touch Screen Technology*

Infrared touch screens are based on light-beam interruption technology. Instead of an overlay on the surface, a frame surrounds the display. The frame has light sources, or light emitting diodes (LED's) on one side and light detectors on the opposite side (Fig. 4), creating an optical grid across the screen. When an object touches the screen, the invisible light beam is interrupted, causing a drop in the signal received by photosensors [6,7].Thus the contact coordinates are determined.

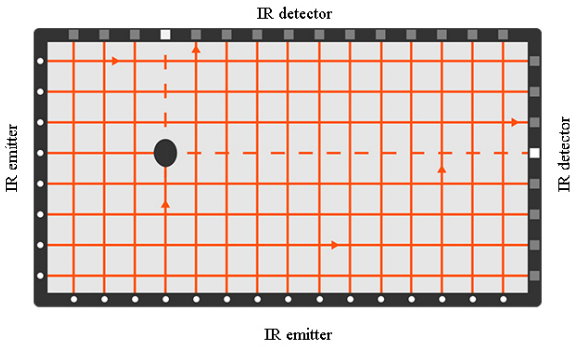

Fig. 4. Infrared touch screen technology (schematic view)

Infrared touch screens, performed in the form of an empty frame (without glass) with sensors installed in it. This constructive feature (empty frame without glass) allows you to use infrared touch screens to register the hit of a dart in the target.

B. *IR Module for Detecting the Hit of a Dart*

The system for detecting the dart hit the target involves the use of two layers of infrared sensors. The corresponding sensors frames are arranged parallel to each other at a fixed distance from the target (Fig. 5).

With an "ideal" perpendicular hit of a dart in the target, the definition of the position of the dart can be realized on the basis of only one infrared frame.

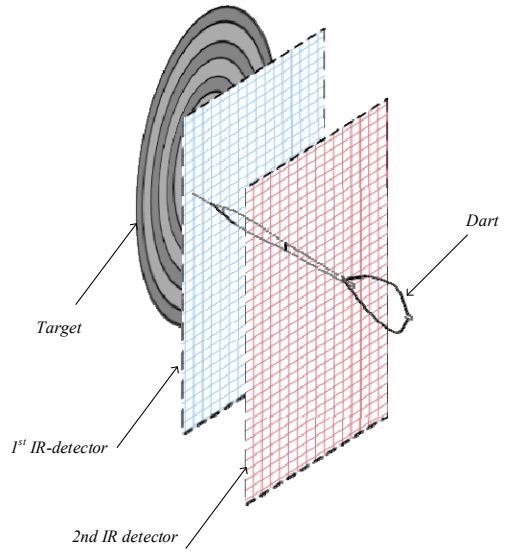

Fig. 5. The system of fixing the target hit on the basis of the IR sensor frame

Under such conditions (perpendicular hit), the coordinate of the dart on the sensor grid is projected onto the target plane.

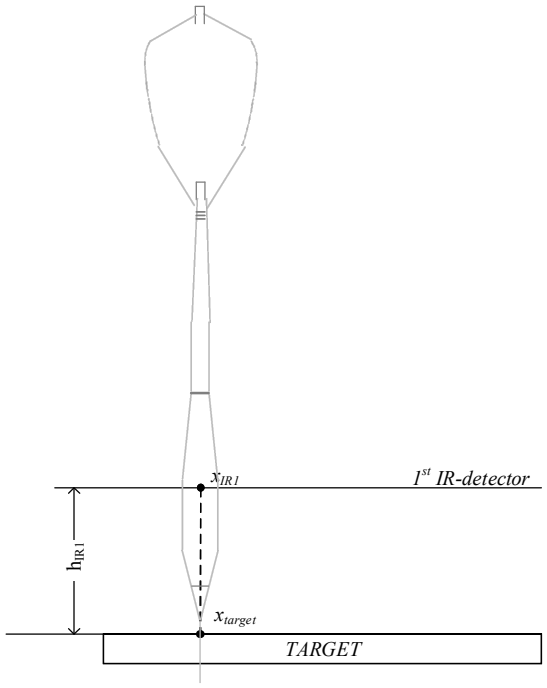

Fig. 6. "Ideal" perpendicular hit of a dart in the target

In this case (perpendicular hit) the x-coord = x_{IR}-coord, and the y-coord = y_{IR}-coord.

The need to use two infrared sensor frames is due to the fact that the arrow position relative to the target can (and usually is) not strictly perpendicular. Usually the arrow is tilted towards the target plane (Fig. 7).

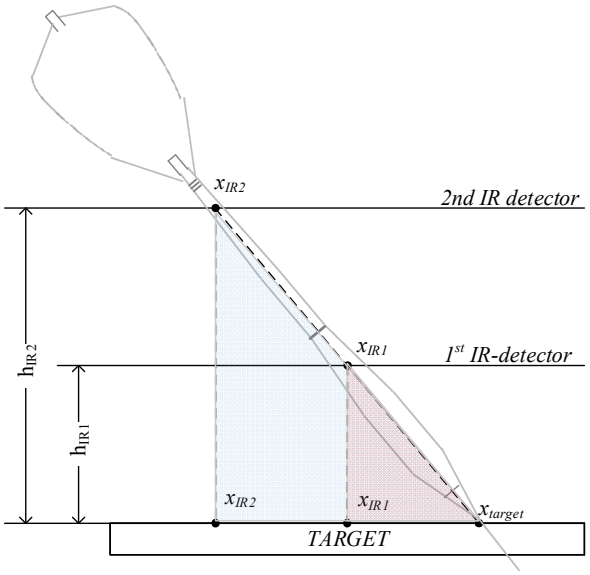

Fig. 7. The arrow is tilted towards the target plane (the mosr popural type of hit)

In case, described on Fig.7, we need to use some equations to determine x_{target} coordinate and the y_{target} coordinate.

The use of two layers of parallel infrared frames allows us to determine the position of the dart in the target in case of non-perpendicular hit.

From similar triangles (formed between a dart and a perpendicular line to the point of its passing through the sensors), we can determine the point of attack on the target (Fig.7).

Schematic to find the coordinate x_{target} (the x-coordinate on target) it is necessary (arording to similar triangles):

$$\frac{h_{IR2}}{(x_{target} - x_{IR2})} = \frac{h_{IR1}}{(x_{target} - x_{IR1})} \quad (1)$$

where

$$x_{target} = \frac{h_{IR2}x_{IR1} - h_{IR1}x_{IR2}}{h_{IR2} - h_{IR1}} \quad (2)$$

By the same principle we can find the coordinate y_{target} (4).

$$\frac{h_{IR2}}{(y_{target} - y_{IR2})} = \frac{h_{IR1}}{(y_{target} - y_{IR1})} \quad (3)$$

where

$$y_{target} = \frac{h_{IR2}y_{IR1} - h_{IR1}y_{IR2}}{h_{IR2} - h_{IR1}} \quad (4)$$

According to the initial settings of the sensory system, the target position of the dart can be determined on the received coordinates.

V. CONCLUSION

In the work is proposed the technology of remote recognition of the image of the dart on the target. The advantages of the proposed technology are:

- Possibility to use professional models of the target with sisal with the possibility of replacing the target as needed.
- Infrared rays do not interfere with the players (they are not visible) and fix the hit.
- The possibility of fixing many hits of the dart - manufacturers offer multi-touch screens (frames) up to 32 points.
- The ability to use any dart (according to the players' tastes).
- Durability and maintainability of the fixation system.

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