SYNERGY OF OPTICAL INSECT COUNTER AND MOBILE ROBOT

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Abstract

Optical insect counter is a new product of our Faculty. It's a high tech application. Using ferromon traps, the flying insects come into the trap. An infra camera is looking the trap. High speed video processing discovers the insects. Video processing calculates the size of the insects and the speed (sign of speed is the direction: in or out). The result is transmitted to the central database, to calculate all insect in an area, field.

Mobile robots can locate the traps more positions, fields. Using GPS receiver every counted insect has position information too (size, speed).

The synergy of using optical insect counter and mobile robots enhanced the coverage of one unit. With these time share method, one trap can measure more position.

The centralized processing can filter the information for fields. Calibrating the alarm levels (for example exponential growing by 10% 5 times, or linear growing by 5% 3 times, …) makes an alarm email or SMS when a specific size of insect (specific type) has dangerous increasing population.

Keywords

optical insect counter, mobile robot

Introduction

Optical insect counters are new high tech applications. It consist many interesting technology: infra camera, high speed video processing using FPGA technology, National Instruments robust field computer: CompactRIO, finally PHP, MySQL web technologies to store the information and present graphs, alarms. We introduce the system details.

Mobile robotic is another exciting technology. Mobile robots are able to move stand-alone mode. With energy harvesting (for example solar panel) they are able to work without traditional external electric power. Mobile robots can use to carry different instruments. In this paper the special instrument is an optical insect counter.

To filter the insects in different position, the database also stores GPS geo positions.

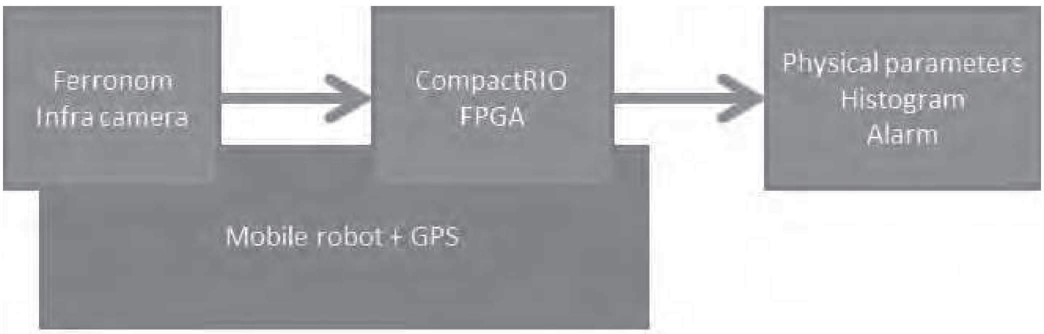

Figure 1. System design, synergy of optical insect counter and mobile robot

The synergy of the previous 3 technology (optical insect counter, mobile robot, GPS) extends the coverage of the counter. The insects have a typical "working hours". One time share option is using optical insect counter in one position with different ferromons. Of course using mobile robots the different working hours can be in different places.

Optical insect counter

There are many different insects, what makes agricultural production losses. There are many technologies to protect against them. One big question to apply the protection is: WHEN? The correct answer, when the insect population is starting growing. We introduce a population calculation method, which count the insect in a ferromon trap. The insect is detected, and using the elapsed time calculated the insect size (length, width) and speed. A central database makes statistical report for a given size of insects.

Infra camera

As earlier said, every insect type has typical working hours. This can be day or night. The optical sensor should see 24 hours a day. That is why we choose infra camera. The camera unit consist an analog infra camera. To process the video signal this unit converts the frames into 3 digital signs. The video processing is simplified to scanning only two lines from the whole picture. It is also a developing area to use high speed line scanners.

The 3 digital signs are the selector of the two lines. The third line is a digitalized video signal. Digitalized means this is a distorted analog video signal. When an insect is at the line: the digital value is high. When the trap is empty the digital value is low.

The video input device makes this conversion. Because of limited power supply this unit use CMOS components. The next unit is working on TTL logical level, so the interface has to convert the signal levels.

Video processing (FPGA)

To find an insect in a video line is a very fast algorithm. One line is 60 μsec long. To measure the width of the insect signal, it must be very punctual to calculating elapsed time between the edges. Rising edge is the beginning of an insect picture, falling edge is the end of the insect.

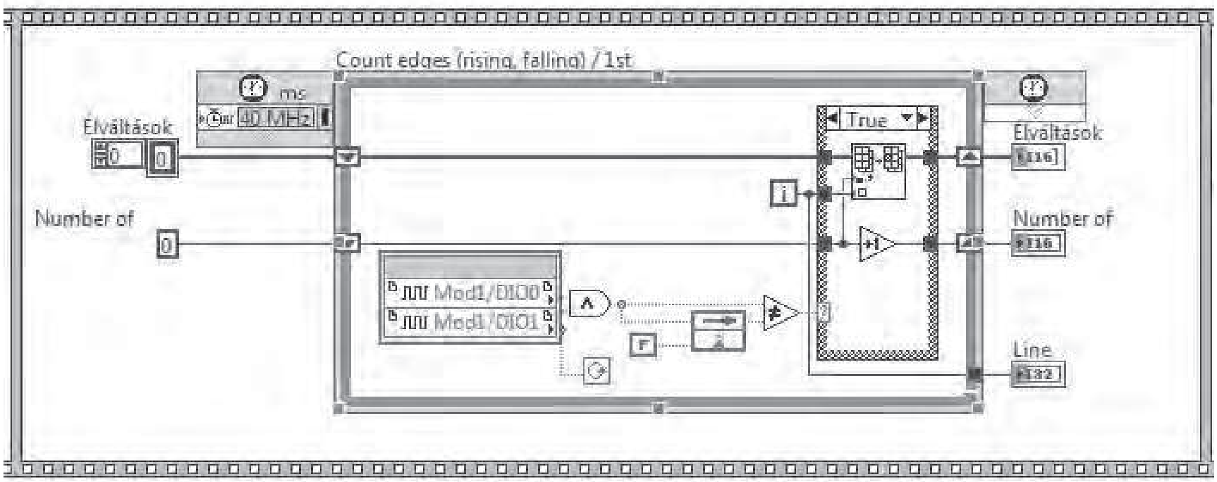

Figure 2. LabVIEW FPGA code for detect edge changing

FPGA technology is a good choice for a fast speed real-time solution. FPGA makes hardware from software. The program code runs in a special hardware what makes exactly what software tells. There is no processor in FPGA, the elementary logical gates makes connected to build a logical gate array. LabVIEW make easy to this coding. Simple graphical code can run on FPGA hardware.

Figure 2 shows the video processing block diagram. The loop works at 40 MHz. It means one line is about 2400 clock cycle. (There are special video signs, so one line is shorter than 60 µsec). Also 2400 count is enough to calculate the insect width.

The pink box symbolizes the digital input signals. DIO1 is the selector signal. The loop is running while the selector is high/true. DIO0 is the digitalized video signal. The AND gate controls the video signal enabled when the select is enabled. The feedback node gets the value from the last loop. Not equal node means the edge changing. When the video signal is not equal with the previous value, this is the edge. The case structure shows the true case. In this case the loop counter store in an array, and increment the array store position.

The loop is finish when the select signal goes false. After it the code give back all of the edge changing position, number of edge changing, and the whole line size.

FPGA programming has a limitation, to use only fix sized array. That's why we should give back the number of edges.

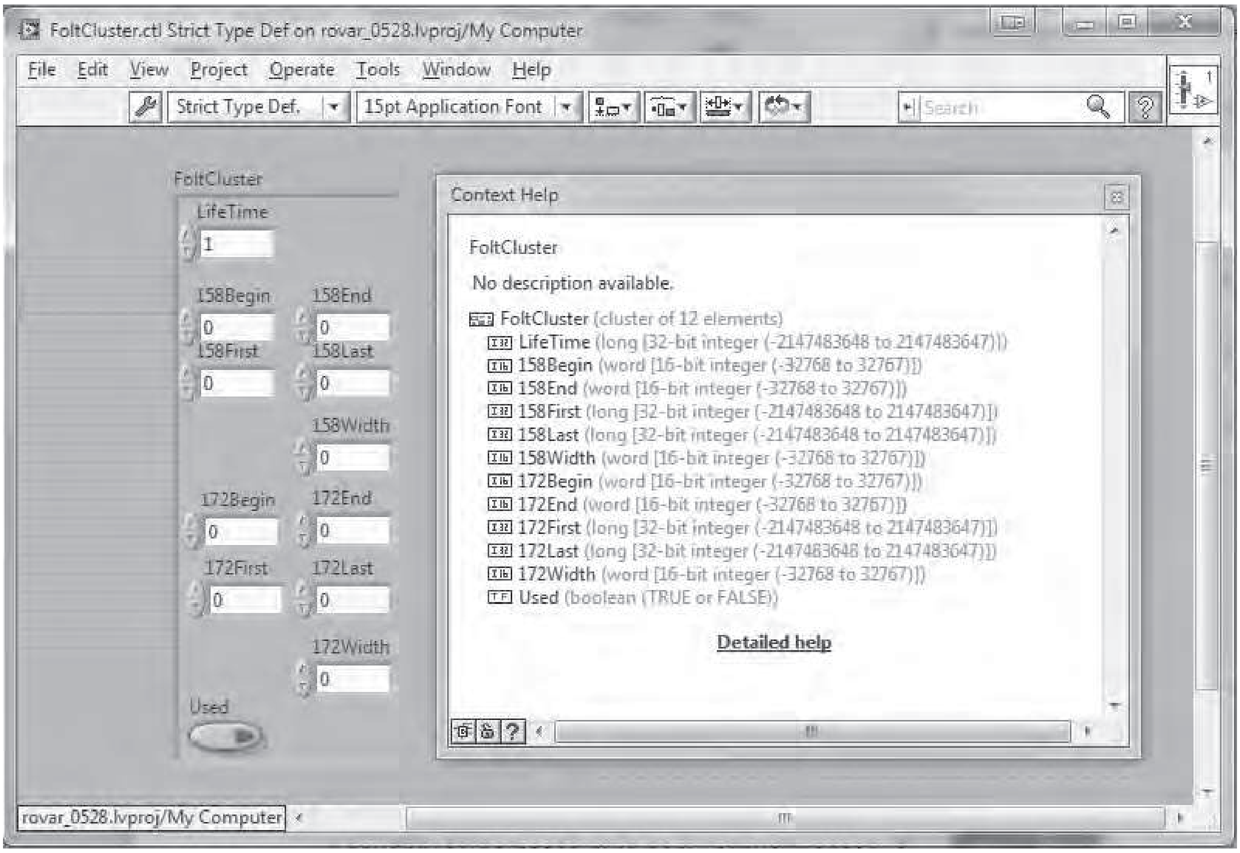

Figure 3. Insect internal data structure

Figure 3 shows the data structure of one insect. The insect can come from two different ways (from the first selected line or the second selected line) and also can leave the camera two directions. There is no rule what will be the first and last.

When both lines are empty, it means no insect in the camera. When the insect arrives one line detect the other line is empty. When the whole insect is before the camera both line detected. When the insect is leaving the camera only one line can see the insect. Finally when both lines are empty again, it means the end of the insect.

The previous scenario is about only one insect. Of course there can be more insects are moving before the camera, moving different directions. The data structure in the figure 3 can store all information about insect arriving and leaving.

Finalizing loop detect when an insect leaving the inspected area. In that case this data structure must be store. For testing it appear in the monitor. The main storage is a centralized web based MySQL database. The data transfer is using URL parameters. Browsing the storage input page, the complete structure stored in the MySQL table.

Using online database require continuous internet access. This makes too much energy. There can be batch process to send the insects by hourly.

Web database

The web part is made by PHP using MySQL database.

The storage input page stores all input information. Figure 4 shows the measured table. There are some special fields, some fields for security. GPS longitude and latitude can be NULL when no GPS unit connected, or GPS signal is not valid. There is a default GPS location for every unit.

For security reason (also can be filtering) at the table the sender IP address is stored. This can be a security filtering, that a special IP range is acceptable. SenderApp is another security fields. Figure 4 shows Mozilla Firefox browser as a sender application. This values are not comes from National Instruments hardware. These values come from optical insect counter test web page. For test reason there is web page where can simulate insect data input.

MeasureID UniqueID	UnitID Mérőeszköz sorozatszáma	Date Mérés dátum	Time mérés ideje	158First Belépés	158Last Kilépés	172First Belépés	172Last Kilépés	Width Szélesség	GPSLong GPS északi	GPSLat GPS keleti	SenderIP Erről az IP-ről jött	SenderApp Küldő applikáció
121	faust1	2011-02-28	20:08:20	1	23	4	25	127	*NULL*	*NULL*	94.44.68.75	National Instruments LabVIEW
122	faust1	2011-02-28	20:09:24	1	23	4	25	127	*NULL*	*NULL*	94.44.68.75	National Instruments LabVIEW
123	faust1	2011-02-25	10:23:00	1	30	4	33	123	47.123	19.543	94.44.65.22	Mozilla/5.0 (Windows; U; Windows NT 6.1; hu; rv:1.
124	faust1	2011-02-25	10:23:00	1	30	4	33	123	47.123	19.543	94.44.72.215	Mozilla/5.0 (Windows; U; Windows NT 6.1; hu; rv:1.

Figure 4. MySQL table. Original measured values

There is a table for original data. There is another table for processed information. Every unit has conversation info. Length and width information can calculate from the measured data and these conversion rates.

$$v = \frac{s}{t} = \frac{d}{\frac{n}{FPS}} = \frac{d \cdot FPS}{n} \qquad 1$$

Speed can be calculated using equations 1.

– d is unit specific distance, physical distance between the two lines (constant),
– FPS camera parameter (constant)
– n is the impulse different between the first and second line.

Using this equation the speed and direction can be calculated. The values can be positive or negative depends on which direction arrive the insect. There are two speed value, incoming and outgoing. If the signs of these values different, it means the insect NOT cross the camera.

After the measured values are converted to physical parameters, we are able to filter the insect by typical insect size and working hour. The reports table stores these filter parameters. Reports are generated regularly (for example every day). If the number of insect (it depends the population) are growing, the alert system is sending the report highlighted the dangerous population/numbers. Traditional protecting methods should be applied that case.

Mobile robot with gps

As figure 1 shown, the optical insect counter can be mobilized by mobile robots. One trap can count not only one place. The mobile robot can carry the trap on the border of a field. Also the mobile robot can carry the trap to another field.

To manage different fields there is a field border table in the database. Mobile traps also can be filtered by time schedule. Using mobile robots extend the coverage of one optical insect counter unit working area.

Possible working extension with mobile robot:

– one field more point,
– more field,
– more measuring points for different working hours.

Figure 5. Mobile robot is moving on fields to mapping with laser scanner

The Pioneer P3-AT mobile robot is able to move on off road environment.

Some parameters of the mobile robots:

- Weight: 11,8 kg (with 3 batteries)
- Axial distance: 275 mm
- Wheel diameter: 225 mm
- Wheel width: 80 mm
- Width (by wheels): 400 mm

Conclusions

Optical insect counter is very useful instrument. The special hardware convert the infra camera video signal into digital signals. High speed video recognition discovers the insects in the camera. The developer algorithm can detect more insect simultaneously, and insect can move different directions.

After detecting an insect the web database convert the counter values into physical distance and speed. The insects can be filtered by size, working hour, GPS position and field area. The reports shows the number of counted insects which is depend on the insect population. Increasing population makes an alert to use protection against the insects.

To carry optical insect counters need mobile robot with off road capabilities. Pioneer P3-AT is a good choice. This mobile robot has advanced navigation system for moving in a changing environment. Using mobile robots extend the coverage of traps.

Nomenclature

CMOS	Complementary metal–oxide–semiconductor
CompactRIO	The National Instruments robust field computer, controller
FPGA	Field-programmable gate array
FPS	Frame Per Second
IMU	Inertial measurement unit
MySQL	open source, multiuser, multithread SQL relational database server, see: SQL
Pioneer P3-AT	All Terrain mobile robot
PHP	Hypertext Preprocessor
URL	Uniform Resource Locator
USB	Universal Serial Bus
SQL	Structured Query Language

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