Intelligent Car Control and Recognition Embedded System

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Agenda

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Objective

- Control and monitoring system with integrated image processing from the camera

- Car localization using GPS and navigation system

- Embedded system to communicate with other control units using CAN bus and industrial internet

- Interface between driver and car integrated system carried out by visualization using LCD panel

Embedded Car System

- Central unit – ARM architecture with build-in 32 bits processor i.MX35

- Used for graphics applications, image processing with object recognition

- Low power consumption preferred for all units

   - Reason for choosing ARM processor
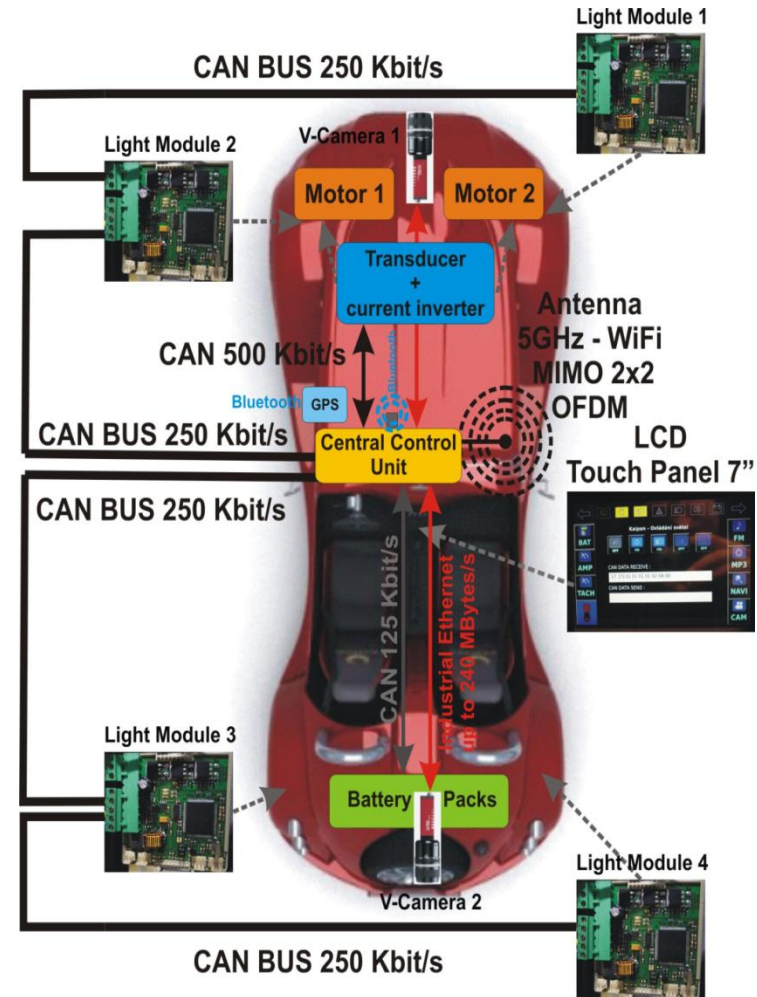
Basic embedded modules in car monitoring system

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Software implementation for Vision

Ability to react to various types of traffic situations

Artificial intelligence needed along with processing image data to predict critical traffic situation

Divided into 3 phases -

1) Testing object recognition algorithms in matlab with cheap webcam

2) Test on mobile devices like PDA

3) Transfer of the recognition system in embedded device which is a part of car system

RTOS Implementation

- RTOS needed to carry out many functions handled by the controlled unit

- 2 types of operating systems thought about – RTAI Linux and QNX Neutrino RTOS

- Communication drivers for RTAI Linux adjusted for wire and wireless connection – FlexCAN, EtherCAT, Bluetooth

RTOS Implementation

QNX Neutrino RTOS easier to implement due to BSP provided by QNX

Problem with wireless communication driver
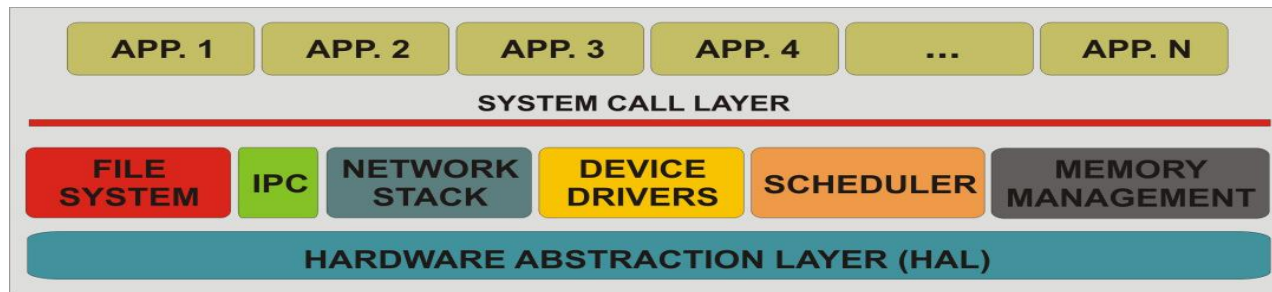
Linux operating system

QNX Neutrino RTOS

QT cross platform framework

QT – cross platform application and UI framework used for embedded applications

Graphics user interface chosen for both operating systems

QT graphical interface applicable for both Linux and QNX Neutrino

Image Scanners

- Developed for traffic signs and traffic lanes detection

- Algorithms based on idea of standardized form and appearance of traffic signs

- Two types of image scanners available – CMOS and CCD technologies

Advantages of two technologies used -

CCD -
Better quality cameras as High luminous sensitivity – better image quality

CMOS –
Much cheaper as based on standard technology. Hence can be placed on chip along with other circuit elements

Scanners Based on CCD technology

Scanners Based on CMOS technology

Algorithms for Traffic signs recognition

Algorithms based on standardized appearance and shapes of traffic signs defined by parameters according to Czech republic government

Algorithms consists of two parts –

1) Correction and segmentation of the input image
2) Object searching , analysis and user information system

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Algorithms for Traffic signs recognition

Image segmentation and conversion

- Search continuous parts in whole figure from a camera
- Converted traffic signs image composed of 5 colors
- where 4 colors (red, blue, black and yellow) determine motive of label
- White chosen as background label
- Converting image to a binary algorithm defined following function :

$$f(p_{(x,y)}) = 0 \text{ for } R_{(x,y)}, G_{(x,y)}, B_{(x,y)} >= h$$
$$1 \text{ for } R_{(x,y)}, G_{(x,y)}, B_{(x,y)} < h$$

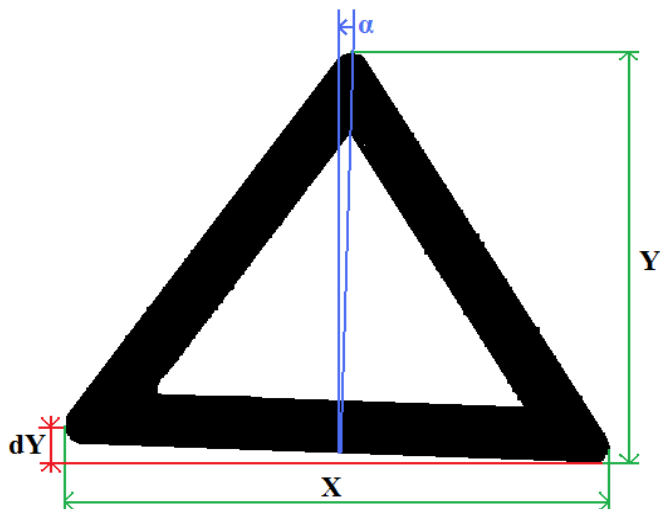Where p : pixel

h : color limit

R,G,B : color components

Algorithms for Traffic signs recognition

Image rotation and angle correction

- Situation occurs to determine angle of deflection from vertical position of traffic signals
- Traffic signals not always installed completely vertically
- Angle calculated by algorithms based on symmetry of traffic signs

$$tg\ \alpha\ = dY/X$$

$$x' = cos(\alpha + 1/tg\ (y/x))\ \sqrt{x^2 + y^2}$$

$$y' = sin(\alpha + 1/tg\ (y/x))\ \sqrt{x^2 + y^2}$$

x',y' – new coordinates

x,y - current coordinates

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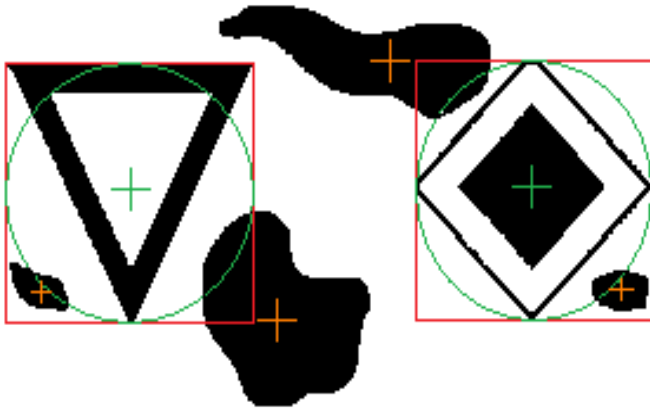UNC CHARLOTTE

Image pattern analysis

- Analyze patterns with actual edited image from the camera
- Traffic signs patterns size standardized at 100X100 pixels
- To apply correlation function, size unification securing of objects and patterns needed
- Function recalculates object's size on defined dimension
- Captured image may contain noise , therefore object segmentation supplemented with object centre identification

Examples of binary matrix
With patterns of traffic signs

Image pattern analysis

- Image processed by analyzing geometric centre of coordinates and objects
- Correlation function – determine relationship between two Signals, similarities of their histories
- Can be expressed as linear, discrete 1D and 2D signals
- New signal expressed as correlation coefficient R. Multiplying this value by 100 represents unity signal in %

Correlation coefficient R ranges from 0 to 1:

$$R = \sum_{x=1}^{x} \sum_{y=1}^{y} f(x,y) \cdot g(x,y) \; / \; x.y$$

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Number Recognition

- OCR – method to digitize texts from retrieved images

- For detection of maximum speed limit, simplified version of OCR applied Segments of traffic signs systematically compared with known pattern of numbers

Patterns for implemented OCR algorithm
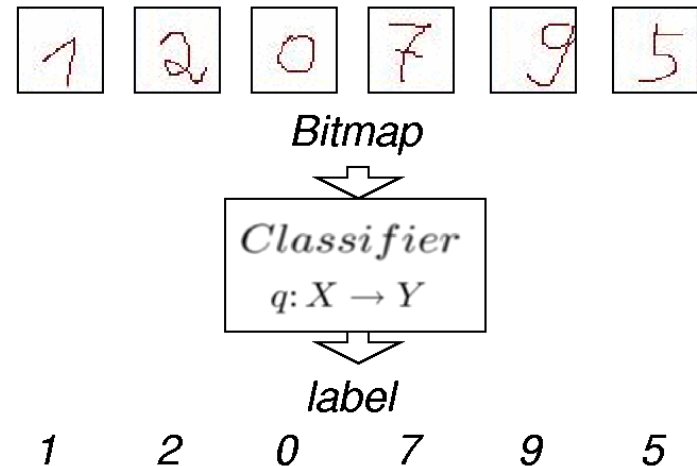
Neural networks

- *Neural networks* - useful for solving problems in image Recognition
- Each element named as neuron
- Neuron receives finite number of inputs and their information
- Passes its output to finite number of outputs information
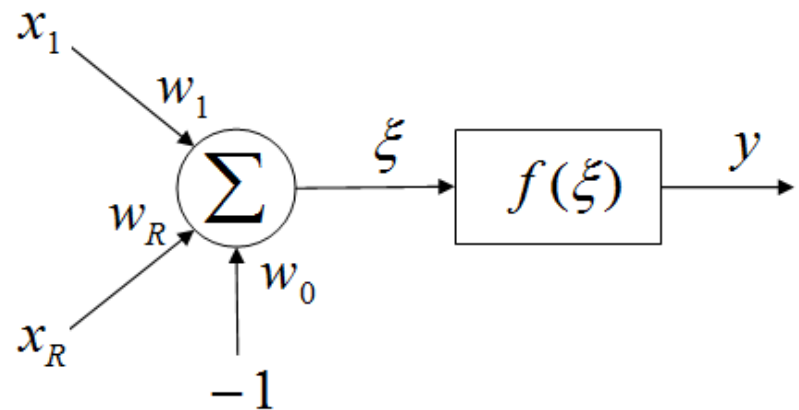
Activity of the neuron – $y = f(\xi)$

Where ξ the so called potential is epressed as

$$\sum_{j=1}^{r} W_j X_j - W_0$$

W_j value of j-th entry

X_j- value of j-th entry of the neuron

W_0 – threshold of neutrons

Traffic lane recognition

➢ For detection of lanes, Hough transform is used Analytical method to find parametric description of the objects in the picture

➢ *Advantages* – robust against irregularities and infringements looking curve

➢ Detection of lines in the images was used in the equation $x\cos\theta + y\sin\theta = r$

R = length of normal from origin to the line

θ = angle between the normal and x
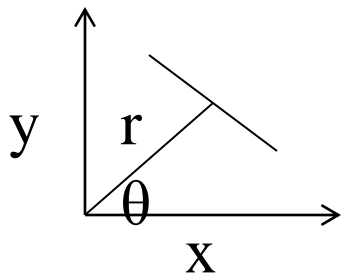
Frame 21   Frame 39   Frame 46
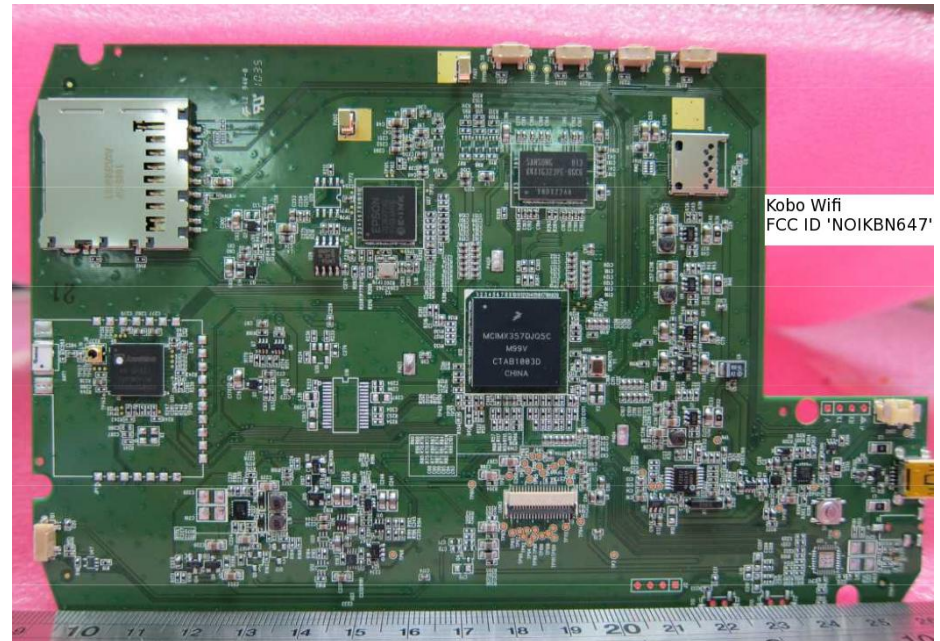
Frame 65   Frame 93   Frame 122

Application Testing

Application created for windows CE, Linux and windows mobile QNX

Testing performed on IMX357 ARM 11 core

- ❑ *Frequency – 532 MHZ*
- ❑ *RAM – 128MB*
- ❑ *Hardware accelerators -*
- ❑ *Image processing unit (IPU)*
- ❑ *OpenVG 1.1 graphics processing unit*

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Application Testing

- Implemented Algorithms suitable for wide range of applications in PDA and mobile phones

- Devices limited by power and memory space

- Application tested on E-TEN Glofiish X650

  - ❏ Frequency – 500 Mhz
  - ❏ Flash ROM -128 MB
  - ❏ RAM – 64 MB
  - ❏ 2Mp Camera
  - ❏ OS - Windows mobile 6

- Testing showed that Reduced performance of the device - largely affected algorithms time consumption

- Algorithms execution time depends upon –

➤ *Size of input image and in turn size and number of objects that are inside this image*

➤ *Performance of the computer on which it is executed*

Results

❖ Verification of software performed on approximately 50 traffic signs

❖ Majority of cases, traffic signs detected correctly

- Successfully recognized with patterns in the range of 90-95%

❖ Sometimes not detected due to excessive pollution or poor light conditions

❖ Distance of signs from the camera plays a big role

- Threshold for identifying traffic signs – 50 mtrs with camera zoom value set to 1:1

Conclusion

- Development of car system for object recognition shown using *two different processors*

- Algorithms for *traffic signs* and *lanes recognition* presented

- Neural networks used in order to solve problems in *image and signal recognition*

- Problem *of image processing and object recognition* with these algorithms discussed

Future scope

- Neural methods and algorithms for OCR analyses are prepared but not implemented although OCR algorithms successfully tested are available

- Look for better function as correlation function has insufficient speed of algorithm execution with increasing number of Patterns

- Consider working on the wireless part for QNX neutrino RTOS

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