Embedded Vision System for Robotics and Industrial Automation

Reinhard Gerndt, Stefan Krupop
from Ostfalia University Wolfenbuettel

Sören Michalik
fromTechnical University Braunschweig

Presented by: **David Hill**

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Agenda

- Introduction
- Motivation
- Picture analysis
  - RGB vs. YUV
  - Edge detection
- Hardware information
- Performance results
- References

Motivation

- Work on a system that accurately provides robotic vision to an embedded system.
- Interact with a soccer ball in confined area and be able to hit it into the goal.
- Help to distinguish objects in the surrounding environment
- Provide a platform into further exploration into vision operations
- Base System requirements:
  - Maximum 4W power consumption
  - Maximum extension of the camera 9cm
  - Maximum weight of the camera 100g

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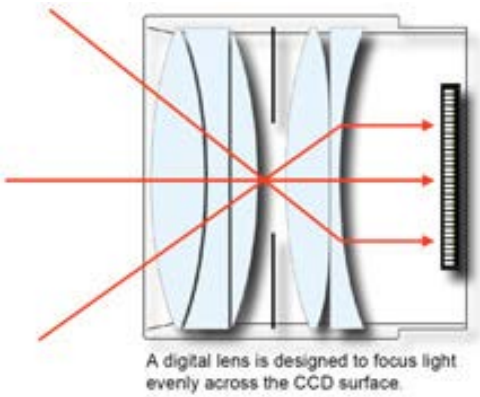
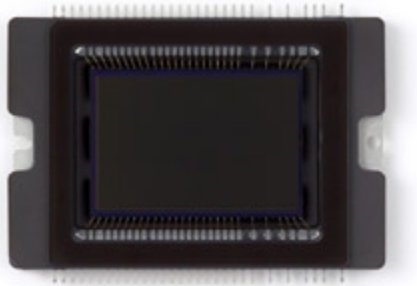
Camera components

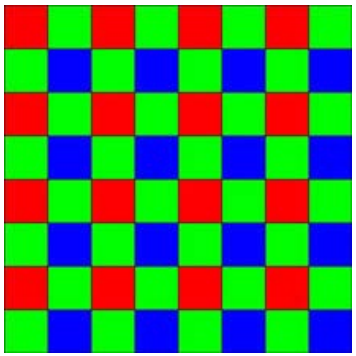
Two main components of a camera:

- Lens
- CMOS transistor

The CMOS compares the values seen and generates an average pixel value at that point.







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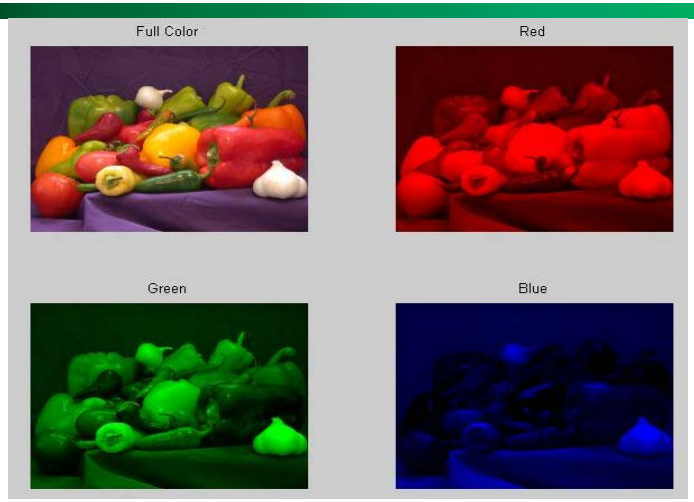
Background on color Analysis



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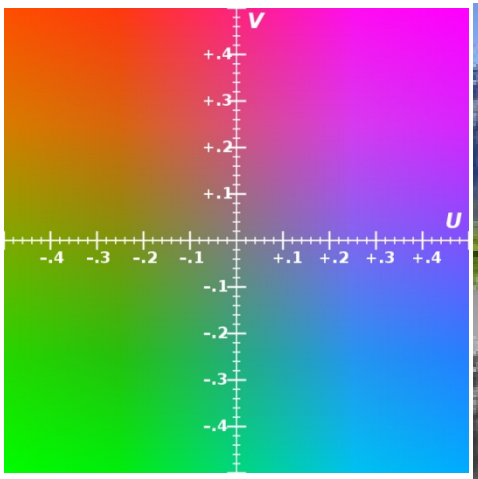

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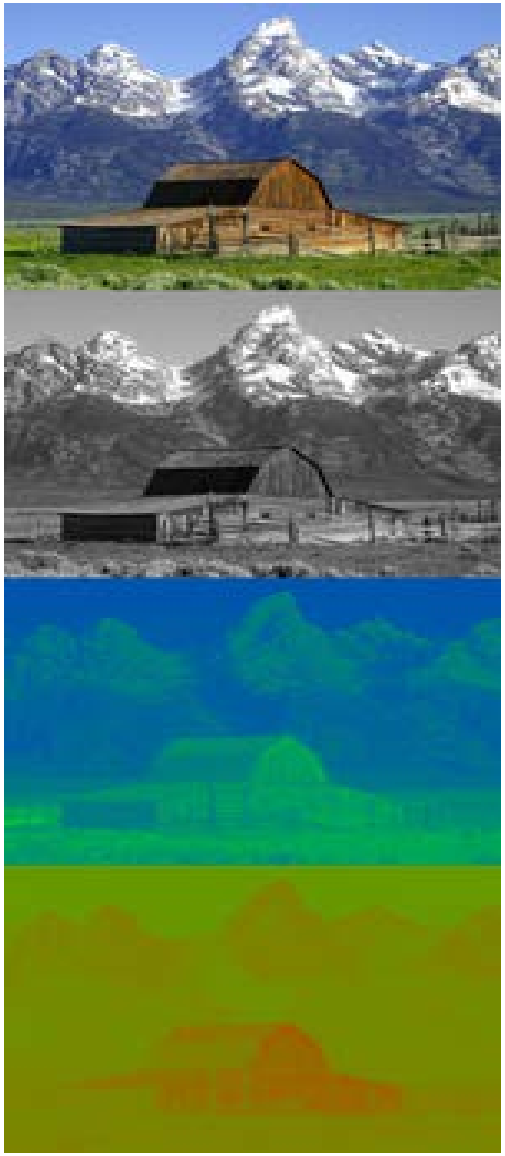


- Traditional imaging devices use the RGB (Red, green, Blue) color space
- The paper went with the YUV (lumanence and 2 chrominance) color space

Image analysis in controlled environment

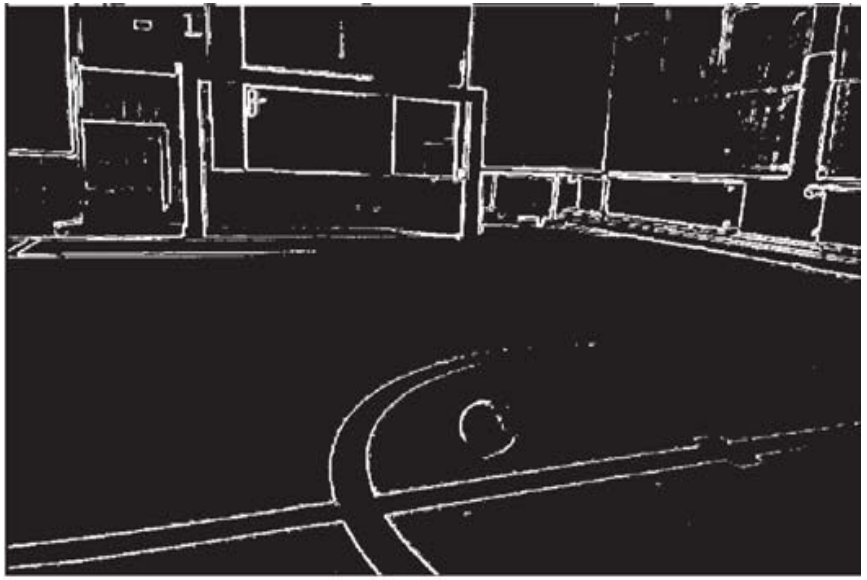
Preprocessing calculations:

$$x_{new} = x_{old}(1 + c_1 r^2 + c_2 r^4 + c_3 r^6)$$
$$y_{new} = y_{old}(1 + c_1 r^2 + c_2 r^4 + c_3 r^6)$$

$$r = \sqrt{(x - x_{center})^2 + (y - y_{center})^2}$$

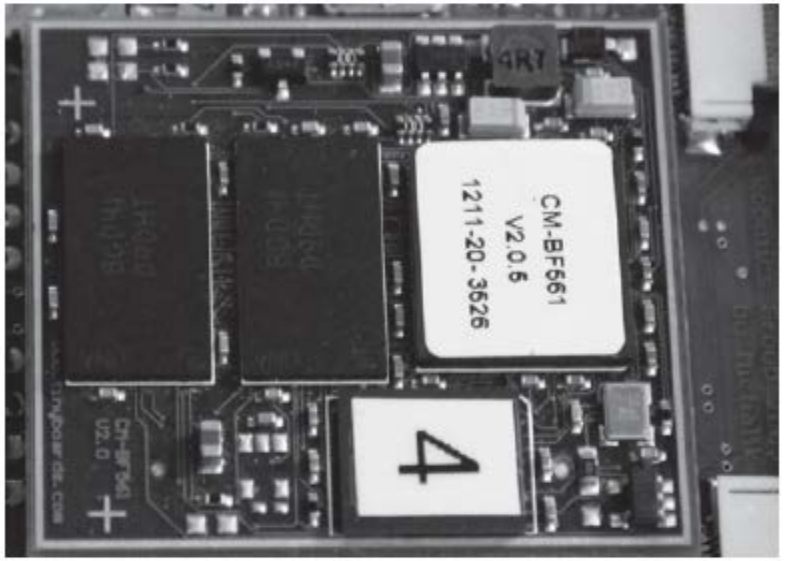
Edge Detection:

$$p_{new}(x,y) = \begin{cases} 1 & if\ T_{\min} < p_{old} < T_{\max} \\ 0 & else \end{cases}$$



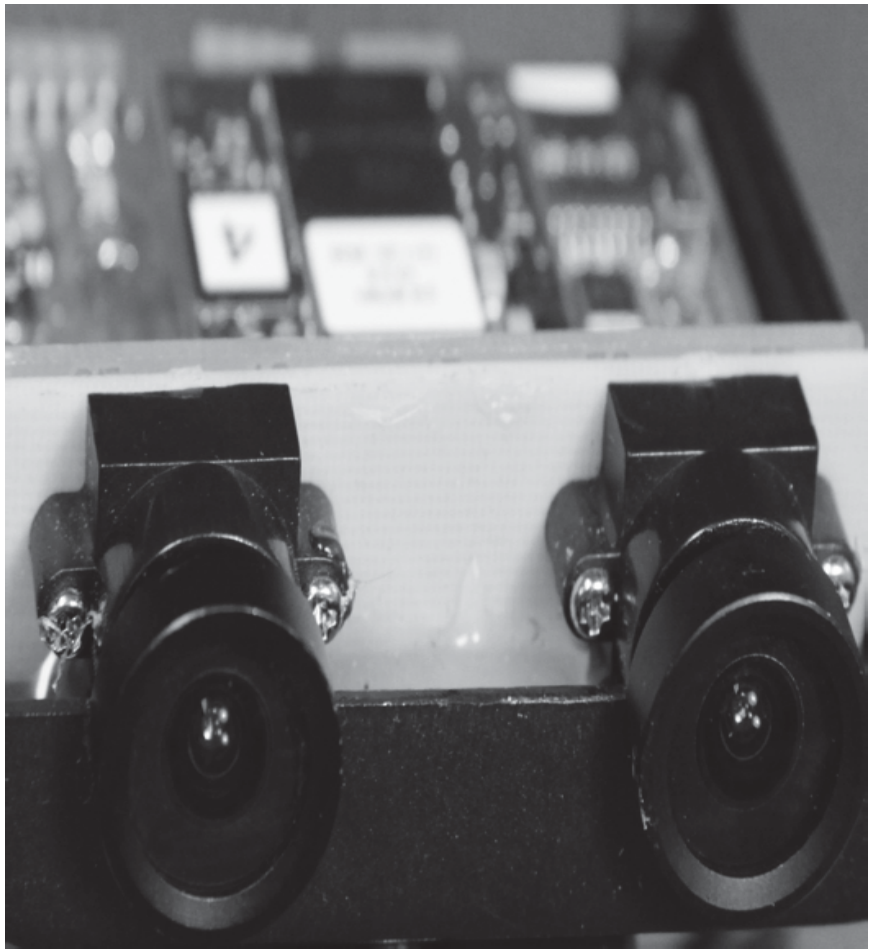
Hardware

Name	Blue techinix CM-PF561
Processor	Blackfin
SDRAM	64 MB
Flash memory	8 MB
Clockspeed	600 MHz
Power consumption	1.7 Watts



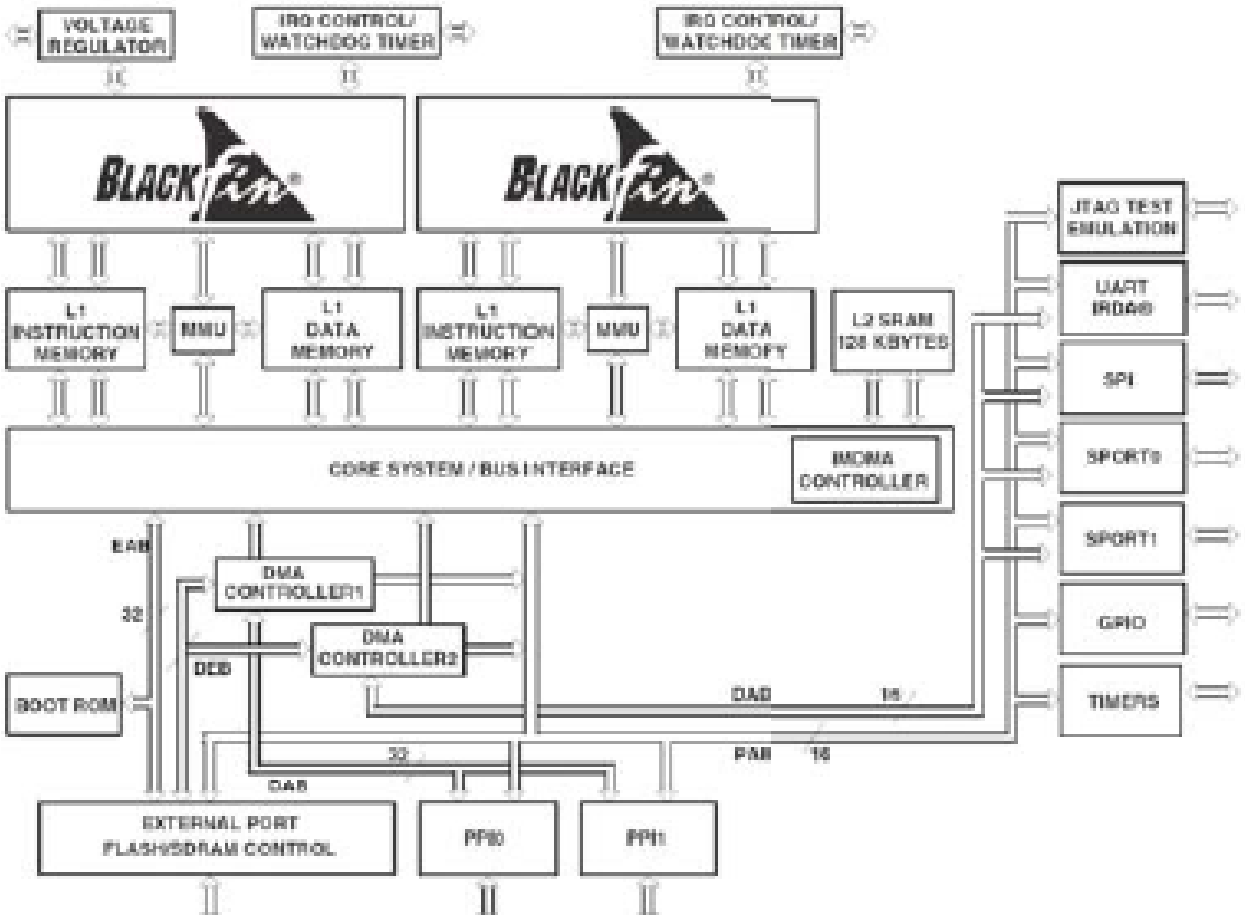
Requirements:
Low power consumption
Low processor requirements

Omnivision camera



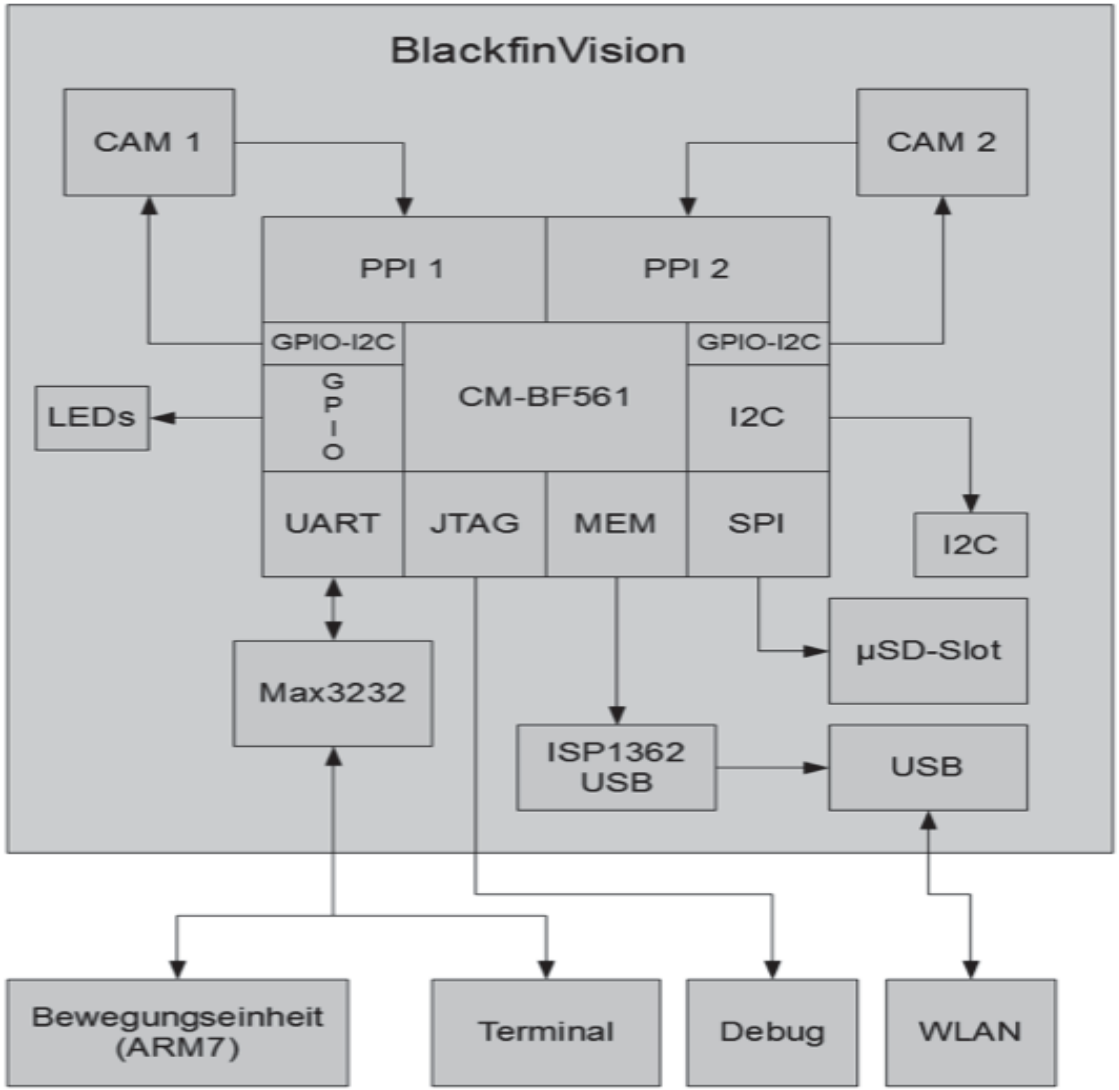
- 1600x1200 at 15 frames a second
- Cmos camera module with SOC
- Output formats : YUV, RGB, and RAW
- Standard lenses can be replaced.

Blackfin architecture



µC-Linux is used as the on the board OS

Vision architecture



UART communication with the rest of the system

Performance comparison

Setup	Minimum	Typ	Max
Stationary	42 cm	46 cm	52cm
Dynamic	35 cm	59cm	68 cm

A few issues arose and forced a drop in performance

Task (Stereo processing)	PC, Core 2 duo	Embedded Vision system
Full frame	55 ms	640 ms
2-fold sub sampling	42 ms	510 ms
4 fold sub-sampling	40 ms	280 ms

Final system

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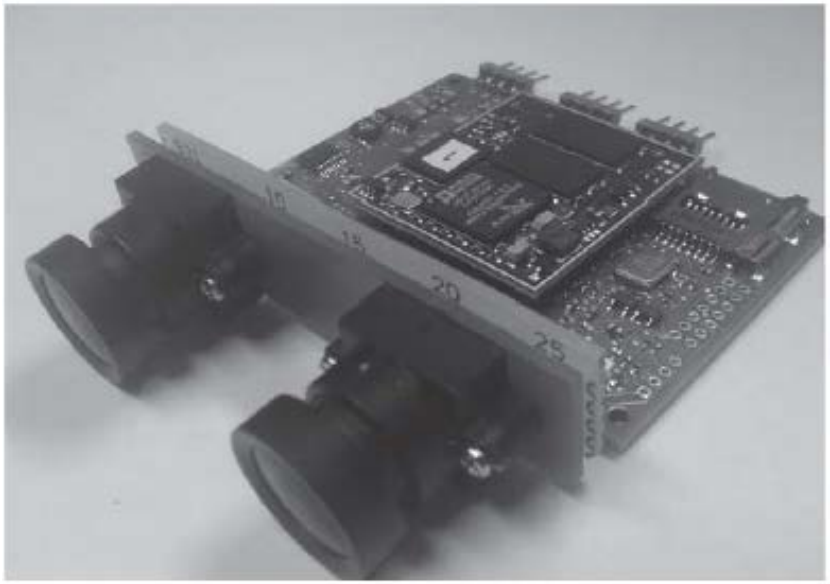

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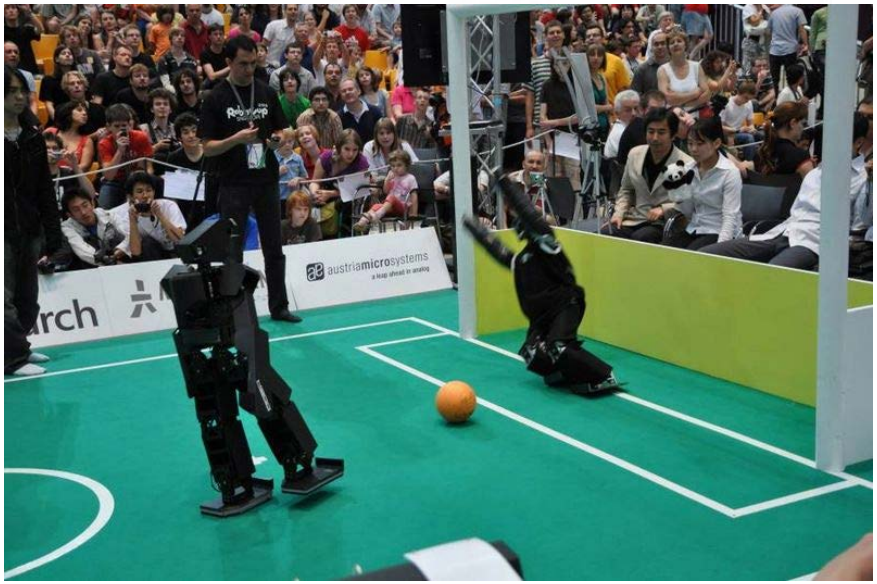

- Optimal resolution of the camera is reduced to 200 x 150
- 120 degree field of vision
- Focal length of 2.5 mmm

References

1. Reinhard Gerndt, Stefan Krupop, Sören Michali. “Embedded Vision System for Robotics and Industrial Automation.”
2. http://en.wikipedia.org/wiki/YUV
3. http://www.mathworks.com/matlabcentral/fileexchange/18125-rgb-image-decomposition
4. http://wiki.robocup.org/wiki/Humanoid_League
5. http://www.cbc.ca/news/background/tech/how-it-works/digital-cameras2.html