# Novel CMOS sensor array for Line Follower Mobile Robots

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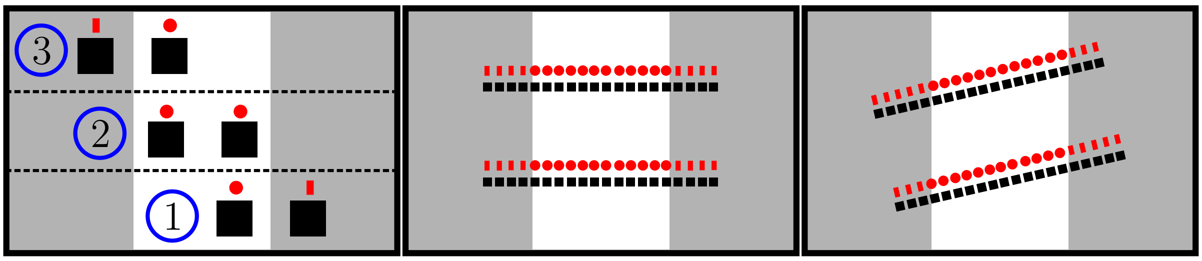
**Abstract**

This work presents the development of a CMOS light sensor linear array, in a standard $0.5\mu m$ CMOS process. Also, it describes the custom setup designed for Line Followers. The location of the sensor cells in the chip is optimized for line detection, where the pixels are arranged in two separated linear arrays. It is described the implementation of the active pixel sensor (APS) with the control system.

## I Introduction

A Line Follower is a mobile robot designed to find and follow a predefined path. This path is commonly marked as a black line over a white surface, or viceversa.

A very important part of a Line Follower is the detection of this line. Generally, light dependent resistors (LDR) or infrared photodiodes are used, because of their simplicity and low cost. The most simple and widely used configuration uses two sensors inside or outside the line (Figure 1a). This method provides information of the side by which the robot has left the line but can not be used to determine the relative position of the vehicle over the path.




(a) (b) (c)

Figure 1: ■ = sensor; ▮ = high level; ● = low level; (a) Two-sensor configuration; (b) Two 32-pixel length array aligned with the path; (c) Misalignment of the path is detected as a difference between the lateral pixel of each array.

In this work it is proposed the usage a 32-pixel linear array, in order to achieve a better position estimation of the robot over the line (Figure 1b). This can only be achieved using integrated sensors, because is expensive and impractical to place this number of sensors above a typically 2cm-wide line. An optical lens is used to focus the line into the integrated sensor.

To further improve the position estimation, the pixels are arranged into two parallel linear array sensors. By knowing the difference in the position detected by both arrays, it is possible to estimate the angle between the line and the robot (Figure 1c).

## II Custom active pixel sensor (APS) Cell

Figure 2 shows the custom active pixel sensor cell used in this work. A standard Complementary Active Pixel Sensor (CAPS)[4] was implemented including a discharge transistor driven by the Select signal.

Each sensor array has two different outputs. The first one is the analog data from each pixel (AOUT), which is obtained through a buffer[3] (not shown in the Figure) and an appropriate time multiplexing control. The second one is a digital output that produces a 32-bit word which represents a discrete value for each one of the 32 pixels. This value determines whether each pixel (DOUT) is above or below of the average analog value of all the pixels. This 32-bit word is shown in Figure 1b.

This is accomplished by sampling and holding two copies of the analog value of each pixel into two separate integrated capacitors. After holding one of these copies, the capacitor is connected later to the capacitors of the other pixels, thus obtaining the average analog value for all the pixels (AVG). The other copy is compared with the previous average in order to obtain a digital value for each pixel (DOUT). The resulting 32-bit word is later shifted out of the chip.

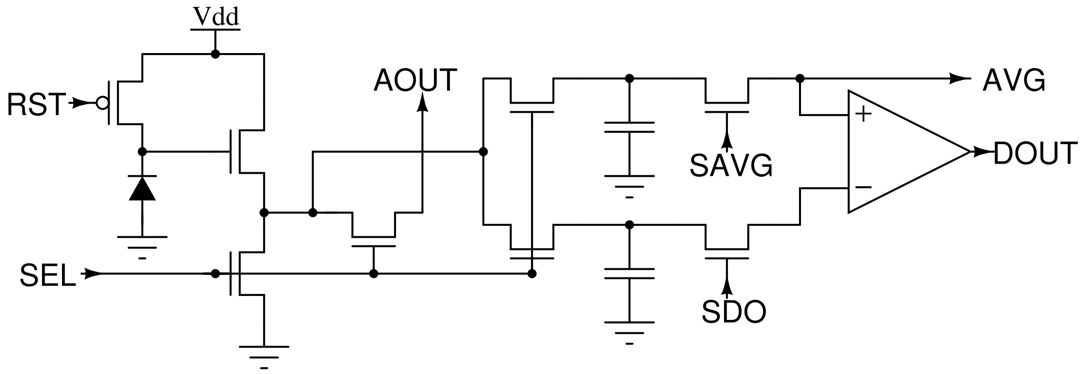



Figure 2: Custom active pixel sensor (APS) Cell

The scope of this poster is the design, modelling, simulation and final layout of the described design which is being fabricated through MOSIS[1] service.


## References

[1] $0.5\mu m$ ONC5 process `http://www.mosis.com/on_semi/c5/`.

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[4] M. Bigas, E. Cabruja, J. Forest, J. Salvi, "Review of CMOS image sensors" Microelectronics Journal, Volume 37, Issue 5, May 2006, Pages 433-451, ISSN 0026-2692