IASTED

Proceedings of the IASTED International Symposium

APPLIED INFORMATICS

Grindelwald, Switzerland
February 16-18, 1988

EDITOR: M.H. Hamza

A Publication of
The International Association of Science
and Technology for Development - IASTED

ISBN 0-88986-097-1

ACTA PRESS

ANAHEIM * CALGARY * ZURICH

THE APPLICATION OF ACSL (ADVANCED CONTINUOUS SIMULATION LANGUAGE) TO ROBOT SENSOR MODELLING

S.R.Ruocco, A.S.White
Robotics Group
Faculty of Engineering, Science and Mathematics
Middlesex Polytechnic, London N11, UK

Abstract

This paper describes the application of ACSL to the validation of a robot vision sensor non-linear mathematical model. The successful implementation of such a model in software helped to predict the sensor output under different operating conditions and has shown to be a useful R&D tool in the development of future generations of vision sensors.

Key words: modelling, simulation, robot sensors

Introduction

Robot vision sensors which rely on light backscattering, such as optical rangefinders, suffer from a low signal-to-noise ratio (SNR) of the returned signal; this latter being particularly low in areas of the image with the highest information content, namely object edges and contours. Several image processing techniques have been developed in order to overcome this problem[1,2,3], mostly using forms of low pass filtering based on spatial convolution and being computationally very expensive.

Images, however, do not have a uniformly poor SNR, that is some regions of the image do have a high SNR whilst others, usually the edges, have a lower one. It follows that a more efficient pre-processing algorithm would only operate on those regions of the image which have an SNR lower than a given value. One such technique is Adaptive Data Acquisition where higher processing priority is given to those pixels which display unattractive statistical properties (i.e. large standard deviation). This latter technique, however, requires several image "frames" to be taken before the statistical check is meaningful thus being potentially slow but providing a significant improvement in image pre-processing efficiency.

Model Driven Data Acquisition: a tool for intelligent sensors

An alternative, efficient data acquisition system has been proposed[4] in the form of the Model Driven Data Acquisition (MDDA) which, in a manner akin to human perception, compares the measured image pixels (i.e. the actual sensor output) to their expected values (i.e. their respective model driven computer calculated values).

This comparison provides a "figure of merit" for each measured pixel which, if necessary, can be remeasured thus concentrating the data acquisition on the areas of the image with the highest pixel value variations.

This latter can be caused either by noise, in the which case this MDDA technique achieves adaptive low pass filtering and therefore reduces the need for image pre-processing, or by model driven artifacts (the equivalent of an optical illusion in human terms) in the which case this MDDA technique simply helps to produce frame averaged images.

Clearly, however, the better the mathematical model on which the computer can base its calculations of the expected pixel values the more efficient the data acquisition algorithm. This paper aims to show how ACSL has helped in the development of a reliable non-linear model for the vision sensor in question by enabling its simulation in software thus allowing model validation by comparison with experimental results.

Robot sensor modelling and ACSL

A model of the 3-D vision sensor has been developed based on its electro-optical front-end[5] and is shown in figure 1. This model is highly non-linear because of the voltage dependent diffusion capacitance C_d and the optical flux coupled to the photodiode φ_s.

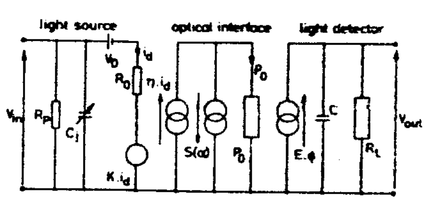
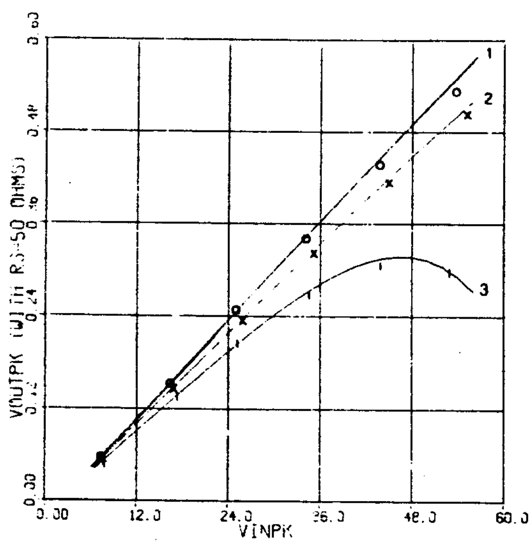


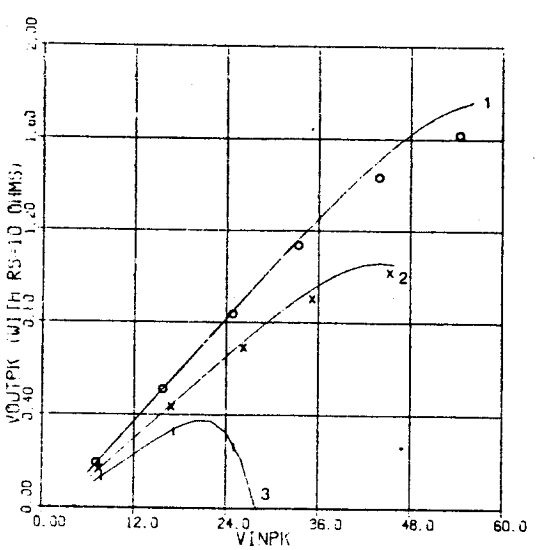
Fig.1 Simplified computer model of 3-D vision sensor front-end

ACSL, the Advanced Continuos Simulation Language, was therefore chosen to implement the model in software because of its capacity for handling non-linear networks, as well as other features such as variable INTEGral algorithms and powerful TABLE statements which allow the inclusion of experimental results within the computer model.

The robot sensor model was thus validated by comparing its ACSL simulation with the experimental results. This is illustrated by figures 2(a) and 2(b) which show a good degree of agreement between the computer predicted sensor transfer function V_{in}/V_{out} and its experimentally measured counterpart under different operating conditions.



(a)



(b)

Fig.2 Sensor front-end transfer function under differrent operating conditions: (a) R_s=50 ohms (b) R_s=10 ohms. Curves 1,2 and 3 indicate the use of different LEDs as light sources HEMT3300, RS308512 and CQX47 respectively.

Conclusions

A computer model of a 3-D robot vision sensor has been developed based on its electro-optical front-end[5] and was simulated using the Advanced Continuos Simulation Language (ACSL). This computer simulation allowed the model to be validated and helped to show that the sensor model thus developed represents a useful R&D tool in the design of future generations of 3-D vision sensors.

References:

1 -Gonzalez R.C. and Wintz P., Digital Image Processing, Addison Wesley,1979

2 -Castleman K.R., Digital Image Procesing, Prentice-Hall, 1979

3 -Rosenfeld A. and Kak A.C., Digital Image Processing, Academic Press, 1982 (Vols. 1 and 2)

4 -Ruocco S.R. and Jones D.H., Model Driven Data Acquisition: a case study, Proc. 3rd Conf. on Sensors and their applications, Cambridge 1987

5 -Ruocco S.R., The derivation of a computer model for the front-end of a 3-D vision sensor, Journal of Optoelectronics, IEE