A HYBRYD OPTICAL/DIGITAL CORRELATOR SYSTEM FOR HIGH SPEED PATTERN RECOGNITION

Fact Sheet

Project Information

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Coordinated by
University of Glasgow

United Kingdom

Objective

Digital simulation has been used to predict the effects on correlator performance of three possible errors when reference images are reconstructed from the angle-multiplexed holographic storage medium. It was shown that, due to the inherent edge-enhancement in phase-only correlation, both scale errors and reductions in image contrast reduced the strength of the correlation peaks. An error of just 2.5% in the relative scales of the FTs almost halved the peak height. Reduced image contrast, with increased background levels, causes both a linear fall in the peak height and an increase in the background levels in the correlation plane. Lateral misalignment between the optically reconstructed FT and the SLM was shown to reduce both the peak heights and the ability of the correlator to discriminate between
different objects. In order to keep these effects to a tolerable level, the optical transform and the SLM should be aligned to within one quarter of an SLM pixel. This work was confirmed experimentally in the final correlator system.

A 3-D attitude estimation technique with OT-SDF filters was presented. The 3-D attitude recognition consisted of estimating the in-plane angle, the 30° out of plane sector and the location in the image, of an industrial component. A method for optically implementing the OT-SDF filters was developed. The filters were constrained to the SLM coding domain. The performance of the constrained filters were compared to those of the original OT-SDF filters. The constrained filters performed as good as the OT-SDF filters, with the exception of some Fourier phase-coded input images.

The final correlator demonstration system employs high speed custom designed FFT processing hardware for the transformation of the input scene and display on the correlator filter plane SLM. The SLM is driven by an imaging board on the output from the FFT system and can correct for aspect ratio, static and dynamic phase distortion and optical non-flatness in real-time. SLMs have also been shown to be capable of being driven at 100Hz, providing the system with additional available processing time. Input to the optical correlator is achieved using a randomly accessed acousto-optically addressed holographic memory. Correlator design is novel with numerous advantages over conventional correlator geometries. This design has been shown to provide shift-invariant pattern recognition with sharp correlation peaks and high discrimination due to the phase-only correlation performed. High speed processing of the correlation plane images is accomplished using a fast CCD camera digitally interfaced to a custom built pixel processing architecture. This processing solves the problem of the data bottleneck which occurs at 2900 frames per second by adopting a parallel approach implemented in programmable gate array devices adapted to the purpose. Out from the correlator assembly comes in the form of object location (x,y) and parametric assessment of the correlation peak quality.

The project aims to create a tightly coupled hybrid optical/digital information processing device that exploits the inherent advantages of state-of-the-art optical and digital technologies. The proposed system offers a solution to the problem of non-contact orientation independent recognition of manufactured geoods, and has the ability to operate at extremely high speed - i.e. 3000 template matching operations per second. This extremely high processing rate makes possible the effective use of two dimensional correlation as a pattern recognition technique for unconstrained object identification. There is an urgent and substantial industrial requirement for high speed quality control, with most applications demanding near to 100% reliability. In particular, applications occur throughout the high volume process manufacturing industries. The system will consist of an electro-optic sub-system comprising: a closely integrated volume holographic memory for the storage of template images, phase modulating spatial light modulator (PM SLM), Fourier
transform lenses and rapid CCD array. A video rate two dimensional fast Fourier transform (FFT) board will be developed to calculate the input image spectrum, the phase component of which will be used to address a phase modulating spatial light modulator (PM SLM). Successive templates, stored as angle multiplexed volume holograms in the fixable photo-refractive material Lithium-Niobate will be optically reconstructed and modulated with the current input scene spectrum during an interval in which the SLM display is held stable. Subsequent optical Fourier transformation will then result in the rapid two-dimensional correlation of the template and input images. Algorithms will be developed that facilitate automated training.

Programme(s)

Topic(s)

Funding Scheme

CSC - Cost-sharing contracts

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