확장 칼만필터를 이용한 홀로그래픽 에러 보정 알고리즘

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Generation of Error corrector for Holographic Data Storage system Used The Extended Kalman filter

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Key Words : EKF, Extended Kalman filter, Holographic data storage system, Inter pixel interference, Bit error

ABSTRACT

Data storage related with writing and retrieving requires high storage capacity, fast transfer rate and less access time. Today any data storage system cannot satisfy these conditions, however holographic data storage system can perform faster data transfer rate because it is a page oriented memory system using volume hologram in writing and retrieving data. System can be constructed without mechanical actuating part therefore fast data transfer rate and high storage capacity about 1Tb/cm^3 can be realized. In this paper, to reduce errors of binary data stored in holographic data storage system, a new method for bit error reduction is suggested. We proposal Algorithm use The Extended Kalman filter. The Kalman filter reduce measurement noise. Therefore, By using this error reduction method following results are obtained; the effect of measurement nois of Pixel is decreased and the intensity profile of data page becomes uniform therefore the better data storage system can be constructed.

1. INTRODUCTION

Holographic Data Storage System[1][2], one of the next generation data storage principle, is a 2-dimensional page oriented memory using volume hologram in writing and retrieving process. In the HDS system, data management procedure is performed in parallel so fast data transfer rate can be realized. And the system stores data in binary form (0 or 1), so that computers can use the digital data directly. In writing procedure, Laser of specific wavelength passes through a Spatial Light Modulator (SLM) to make 2-dimensional data page. A digital data 0 makes image of a black pixel (off-pixel) by blocking the light on SLM and digital data 1 is imaged as a white pixel (on-pixel) on CCD camera.Diffraction, the nature of light, makes the laser which passes through an on-pixel surrounded by off-pixels on SLM to affect surrounding pixels by 2-dimensional Fourier Transform of a plane wave and when retrieving process the effects to surrounding pixels of an on-pixel are photographed by CCD camera and cause errors to binary data.

In this paper, we analyze the effect of an on-pixel (digital data 1) to surrounding off-pixels (digital data 0) and suggest a new method for reducing errors of binary data using The EKF(Extended Kalman Filter).[6]

The error reduction algorithm is that; reduce measurement noise used The Extended Kalman filter, write binary data and reconstruct binary data. Fig. 1 is the HDS system experiment test bed.

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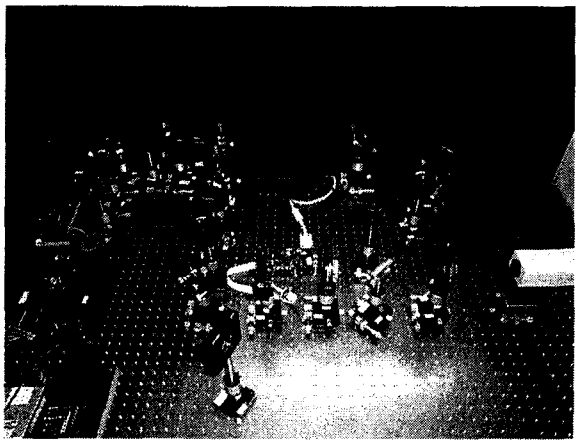


Figure 1: HDS system experiment test bed

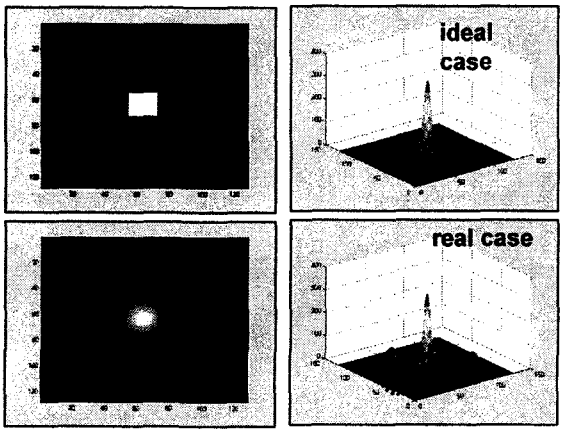


Figure 2: Beam intensity profile after passing through a rectangular aperture

2. IPI Noise and subtractive clustering algorithm

2.1 IPI Noise

By the Fraunhofer diffraction theory, the beam from the laser source emits as a plane wave. However after crossing the aperture – SLM, the beam propagates as a spherical wave from many point sources and diffracts. The on-pixels of SLM allow the beam to pass through, but the off-pixels do not. So an on-pixel acts like as an aperture, and the beam through the on-pixel of SLM will affect to surrounding pixels by 2-dimensional Fourier Transform[2].

This effect acts as one of main noises, and is called "Inter Pixel Interference" noise. Inter Pixel Interference (IPI) degrades the performance of the channel, and it tends to occur when an off-pixel is surrounded by on-pixels or vice versa. Where there are many on-pixels in comparison, errors from IPI noise will appear relatively high than other area of data page. Therefore if we find the cluster of on-pixels and reduce the intensities of the on-pixels, the possibility of error by IPI noise will decrease than before. And about the whole data page because the intensity of laser of brighter area will be decreased, uniform intensity profile will be obtained. The IPI noise from 2-dimensional Fourier Transform is shown in Fig. 2.

3. The Extended Kalman Filter

3.1 The EXF Algorithm

Tbale 3.3 states the EXF[6] algorithm. In many ways, this algorithm is similar to the Kalman filter algorithm stated in Table 3.1. The most important differences are summarized by the following table:

That is, the linear predictions in Kalman filters are replaced by their nonlinear generalizations in EKFs. Moreover, EKFs use Jacobians G_t and H_t instead of the corresponding linear system matrices A_t, B_t and C_t in Kalman filters.

The Jacobian G_t corresponds to the matrices A_t and B_t, and the Jacobian H_t corresponds to C_t.

Table 1. The extended Kalman filter algorithm

1:	Algorithm Extended_Kalman_filter($\mu_{t-1}, \Sigma_{t-1}, u_t, z_t$):
2:	$\bar{\mu}_t = g(u_t, \mu_{t-1})$
3:	$\bar{\Sigma}_t = G_t \Sigma_{t-1} G_t^T + R_t$
4:	$K_t = \bar{\Sigma}_t H_t^T (H_t \bar{\Sigma}_t H_t^T + Q_t)^{-1}$
5:	$\mu_t = \bar{\mu}_t + K_t(z_t - h(\bar{\mu}_t))$
6:	$\Sigma_t = (I - K_t H_t)\bar{\Sigma}_t$
7:	return μ_t, Σ_t

4. Simulations

Fig. 3 is a data page made by applying IPI noise from 2-dimensional Fourier Transform to the original data page. After reconstruction the digital data from the data page with IPI noise with threshold method, 61 numbers of pixels are reconstructed different from the original pixels.

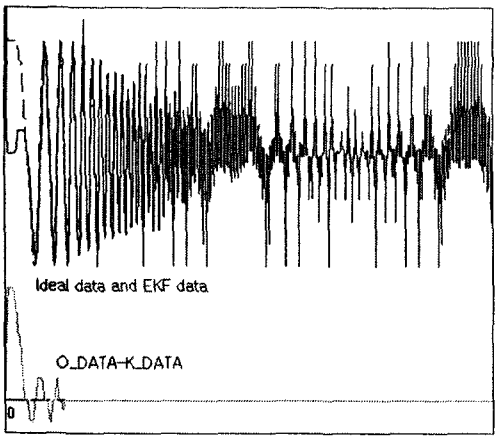
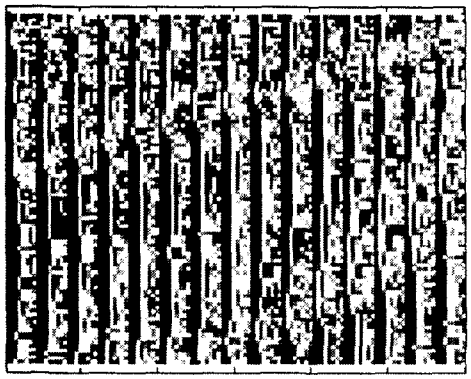


Figure 3: Example of Error correct by The EKF


(a) The original data page with IPI noise

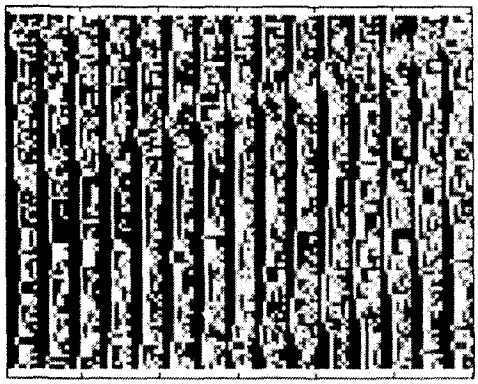

(b) The original data page with IPI noise and measurement noise

Figure 4: The original data and The measurement data

Figure 3 shows the Error correct by The EKF. Figure 4 shows the photographed image of the original data page by CCD camera and the original data page with measurement noise. Figure 5 shows the binary data page of modified data page

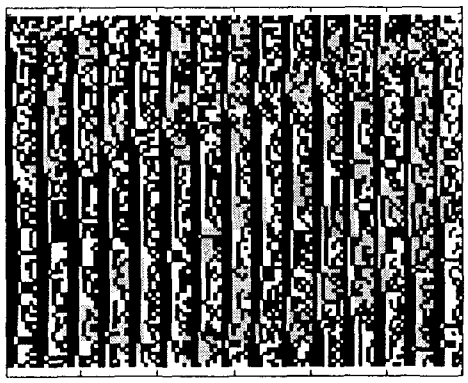


Figure 5: The modified data page

It can be perceived that intensity profile of the modified data page by applying suggested error reduction algorithm is more uniform than the original data page.

5. Conclusions

The measurement noise is one of the main sources which induce errors in HDS system. And for accuracy in writing/retrieving processes, intensity profile of the data page to be stored is good as uniform as possible.
In this paper, by using The EKF(Extended Kalman Filter) algorithm where there are many on-pixels in comparison are found and intensities of the pixels consist of the region are reduced by a specific value.

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