Digital Data Storage on Microfilm • The MILLENIUM Project: Hardware Realization

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Abstract

The MILLENIUM project, funded by the German Federal Ministry of Economics and Technology (BMWi), aims at providing a technological solution for the workflow of digital data storage on microfilm. We describe the hardware chain that is necessary to record and retrieve digital data recorded on microfilm. The laser recorder as well as the film scanning system for reading is presented. Interdependencies between these basic hardware modules are shown guiding to the specifications which are realized in MILLENIUM. Data test recordings with different resolutions of the data on the film are described.

Introduction

Laser recording of digital data on microfilm for long-term storage is an emerging technology in the archiving sector. The microfilm's estimated lifetime exceeds 500 years. Data storage on microfilm thus eliminates the need of time-consuming and costly migration steps. As a real WORM (write once read many) medium, microfilm guarantees a high level of data security. Furthermore, this innovative storage medium offers the possibility for hybrid storage of digital and analog data on the same medium. A considerable amount of digital data has been generated in the past years without long-term storage concepts. Microfilm data storage features zero handling costs by eliminating the need for data migration and could be used as a long-term storage solution for all digital archives.

The cooperation partners of the MILLENIUM project, Fraunhofer Institute for Physical Measurement Techniques (IPM) in Freiburg, and the Institute for Communications Technology (IfN) at Technische Universität Braunschweig, as well as several small or medium sized businesses, developed a high-resolution laser recording system and signal processing and coding algorithms [1]. This paper focuses on the description of the hardware.

Microfilm Scanner Hardware Specifications

Current roll film scanners use a line scan CCD sensor with typically up to 8192 pixel. This corresponds to a symbol pitch on a 35 mm roll film (net image height 33 mm) of appr. 4 µm. Due to the fact that the actual symbol pitch has to be at least twice the sampling frequency defined by the pixel pitch, the symbol grid has to be larger than 8 µm to allow the resolution of individual bits. For an increased data density, a roll film scanner with a smaller pixel pitch is needed. To our knowledge, the roll film scanner with the smallest pixel pitch currently available is a system developed for geospatial photogrammetric scanner with nominal pixel pitch down to 3 µm (DSW 700 brand Leica Geosystems). This pixel pitch would correspond to a symbol grid of 6 µm.

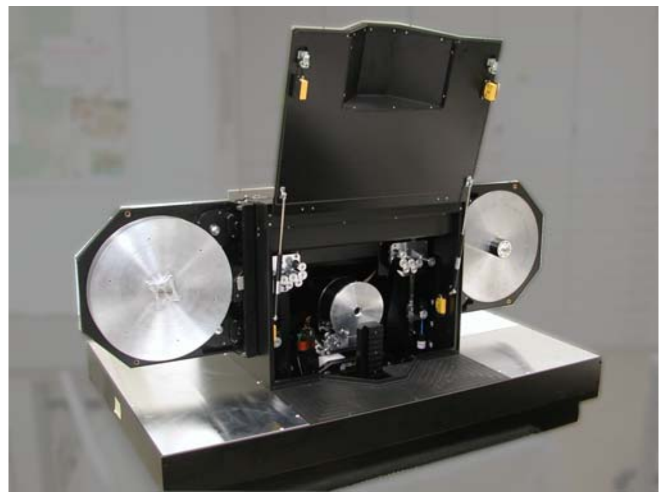

Figure 1. *MILLENIUM laser recorder with open front hatch and two open film magazines.*

Within the MILLENIUM project, experiments with 6 µm and 9 µm symbol grids have been conducted. Both symbol grids have been recorded (the 6 µm with reduced contrast) with the Arche laser recorder [2]. For increased data density, the MILLENIUM data recorder with a symbol grid of 4 µm was designed. With this symbol grid spacing, even higher data densities can be written, though currently available microfilm scanners limit the maximum usable data density.

Laser Recorder Hardware Specifications

The MILLENIUM laser recorder (Fig. 1) writes data onto microfilm by scanning a modulated laser beam along two directions, the slow and the fast scanning axis. The prototype of the recorder build by Fraunhofer IPM contains a directly modulated 405 nm diode laser (brand Omicron Laserage Laserprodukte GmbH) modulated with a frequency of 165 MHz. The actual modulation frequency is controlled by the speed of the fast axis scan prism (fast scan axis) which rotates at frequencies of 1 – 1.5 kHz. The slow axis scan of the laser beam is realized by a linear motor (brand: Micos) with high precision movement control. The film is written frame-by-frame with a frame size of 32 mm x 200 mm which corresponds to 8,000 x 50,000 pixels. This corresponds to a gross data density of appr. 50 MByte per frame.

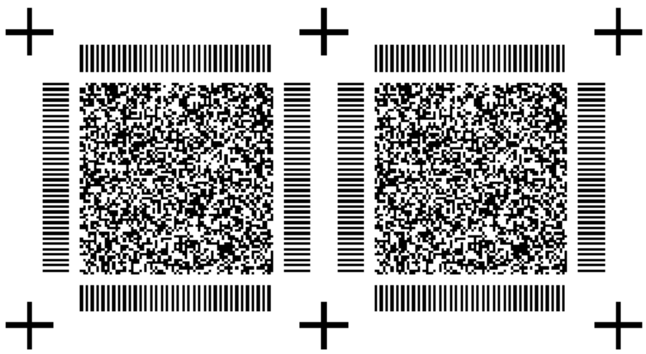

Figure 2. *Two sections of the test patterns with synchronization marks and data bits. Complete test pattern size is 8,000 x 50,000 pixels.*

For testing purposes, a data page consisting of different symbol patterns was designed by the Institute for Communications Technology (IfN) in Braunschweig, Germany. The test pattern consists of several patches with synchronization marks and data bits (Fig. 2).

The evaluation of the rescanned test pattern indicates that existing roll film scanners can retrieve digitally stored data with a symbol pitch of 6 µm to 9 µm. The optimum symbol pitch depends on the bit error rate determined by both the laser recorder spot size and the microfilm scanner resolution. A detailed analysis will be published as part of the MILLENIUM final project report. The MILLENIUM prototype laser writer has the potential to write symbol pitches down to 4 µm which is smaller than the minimum symbol size retrievable by currently available microfilm scanners. To make full advantage of the high data density of the MILLENIUM prototype laser writer, further development on a high resolution microfilm scanner is thus needed.

References

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Author Biography

Dominik M. Giel graduated in laser physics (2000) at Bonn University and received his PhD from Duesseldorf University (2004) for his work on hologram tomography. He focused on optical information processing during a post-doctoral visit at Caltech, CA, and joined the Fraunhofer Gesellschaft in 2004 where he heads the department of Laser Recording and Holography Systems.

Andreas Hofmann received his diploma in Physics in 1995 at the University of Freiburg. Until he came to Fraunhofer IPM in 2000 he worked in several laser companies. He is the project coordinator of the MILLENIUM project.

Wenzel Salzmann received his Diploma degree in physics from the University of Tuebingen in 2002. He did his PhD in laser physics at the University of Freiburg (2007). Since then he has worked in the Fraunhofer IPM, focussing on the development of laser recording systems and optical 3D display technologies.

Christoph Voges received his Dipl.-Ing. degree in Electrical Engineering from Technische Universitaet Braunschweig, Germany, in 2005 with major subject information technology. During his studies he visited the University of Southampton, UK, as an exchange student. After his degree he joined the Institute for Communications Technology in Braunschweig, Germany. His current research interests include signal processing, coding, and storage technologies. He is particulary working on modulation, channel coding, and channel models for microfilm as a medium for long-term data storage.