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Camera Imaging System

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Abstract

- Magnetic shape memory alloys are functional materials which can remember their shape
- Currently, twin boundaries as a function of magnetic field angle can not be measured
- Information about shape changes of different parts of the sample will increase the understanding of deformation mechanisms

Disciplines

Electrical and Computer Engineering

Camera Imaging System

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Problem Statement

- Magnetic shape memory alloys are functional materials which can remember their shape
- Currently, twin boundaries as a function of magnetic field angle can not be measured
- Information about shape changes of different parts of the sample will increase the understanding of deformation mechanisms

Objective

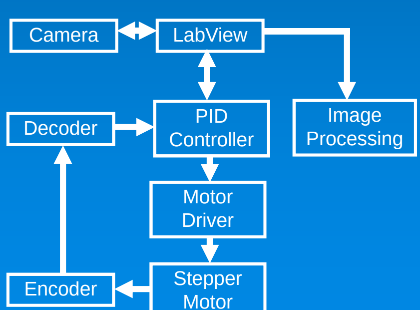
- Build a control system that rotates the sample at user defined, repeatable intervals using a rotation apparatus
- Develop an image processing algorithm to find shape change and detect twin boundaries

Figure 1: Vibrating Sample Magnetometer (VSM) with electromagnet and rotation apparatus (OMMD) inserted between the pole pieces. The motor and camera used to take images is missing in this image.

Constraints

- No rotational overshoot
- Repeatability with +/- 1° Accuracy
- No vibration from Motor
- Accurately detect and characterize twin boundaries
- Expenses not to exceed $500

Project Block Diagram



Controls System

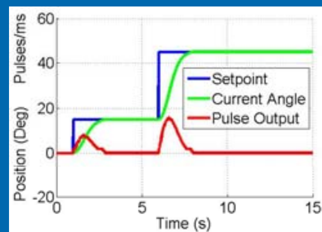


Figure 2: Results from the simulated PID control loop in Matlab. Note that there is no overshoot. The physical system can be modeled with this simulation and provides a great way to experimentally find the optimal parameters for the final system.

Simulation

- Matlab simulation model
- Accounts for inertia
- Provides base for designing physical system

Physical System

- Closed PID loop implemented on Atmel ATMega324 microcontroller
- Conversion from Pulse width modulation to frequency modulation
- Motor control via stepper motor driver
- Mechanical implementation of incremental encoder
- Decoder chip for interfacing with rotational encoder
- RS232 communication

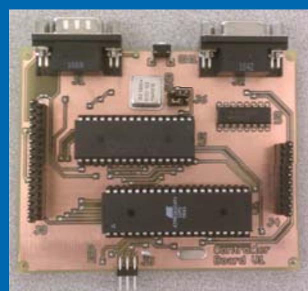


Figure 3 (top): Controller board with Atmel microprocessor and decoder chip. Two DB9 connectors provide connectivity to an encoder and the controlling computer.

Figure 4 (right): Shown is the stepper motor and the rotational encoder mounted on the rotational device. The motor is geared down by 5:1 while the encoder is directly connected to the device's shaft. Camera and optics can be seen in the back of the device

Image Processing

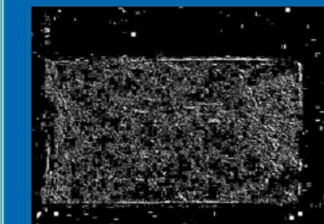


Figure 5a – Motion Detection

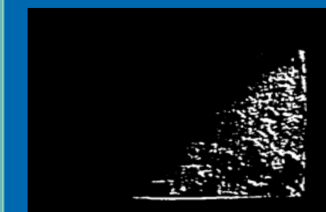


Figure 5b – Filtering and Thresholding

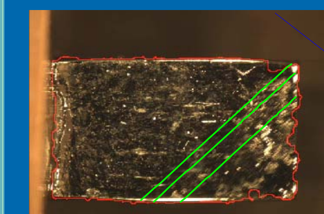


Figure 5c – Final Result

Implemented Functions

- Shape detection (Edge Detection)
- Motion Detection
- Line Extraction (Twin Boundary Analysis)
- Visualization of Magnetic Field

Approach

- Horizontal and vertical Sobel filtering for edge detection using HSV image matrices
- Hough Transformation for line extraction
- Morphological image processing for strain analysis

Figure 5: a) Result from motion detection with background noise present. b) Filtering and thresholding results in the desired detection of the part of the sample that moved. c) Processed image. The edge detection clearly detects the sample's shape (red), while the detected twin boundaries are highlited in green. The blue line indicates the angle of the applied magnetic field.

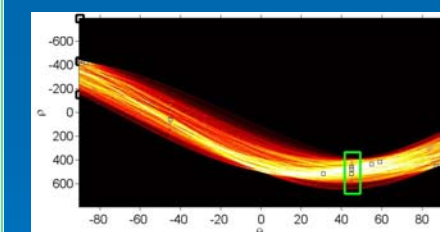


Figure 6: Results of the Hough transformation which is used to find twin boundaries. The green rectangle shows that peaks occur at +45 degrees. Usually, twin boundaries occur at a fixed angle of 45 ± 3 degress to the sample's X or Y axis.

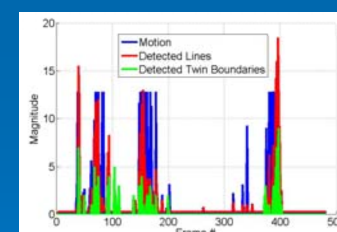


Figure 7: Results from the twin boundary analysis. The relative magnitudes give researchers an idea how well the algorithm worked and if parameters need to be adjusted.

Conclusions

- Automated controls system
- Visualization of sample's shape change
- Twin boundary detection without the use of polarized light
- Portable and flexible system that allows future expansion

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