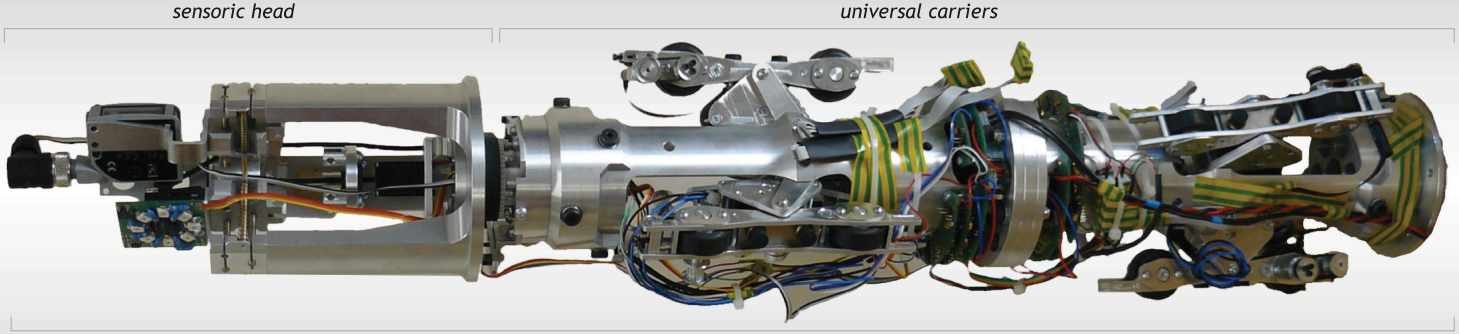
SCANNING AND MEASURING DEVICE FOR DIAGNOSTIC OF BARREL BORE

1, Introduction

This poster discusses the design, mechanical design, electronics and software for robot that is able to diagnose barrels with caliber of 120 mm to 155 mm.

This diagnostic device is intended primarily for experimental research and verification of appropriate methods and technologies.



barrel diagnostic robot

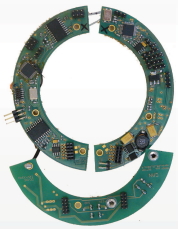
2, Hardware

a) Mechanical design

- Robot consist of two main parts: sensoric head (described in 3.a) and universal carriers. Carrying part of diagnostic equipment is versatile robot's body. Almost all electronics which is responsible for controlling the engine of the devices and which communicate with the external environment are located on the body of the robot. The body has no sensors. It serves only as a movable part, which has the task of adapting to the caliber of the scanned barrel to ensure smooth movement within the barrel.It consists of several important parts:
  - Versatile carrier is divided into two halves, which are identical in terms of engines.
  - Driving system, which consists of six miniature geared engines and wheels.
  - Centering mechanism which provides expanding of arms with driven wheels. The arms can be adjusted by the stepper engine from the caliber 120 mm to 155 mm.

b) Embedded system

- The proposed electronic system can be divided into several parts:
  - Modules for the movement of the robot in the barrel
  - Mechanism to keep the robot in the center of barrel (expanding arms)
  - Turning sensoric head
  - Modules for collecting data from a sensoric system
- All modules of the system communicate on CAN 2.0A bus using CANopen protocol



Detail of the electronic semicircles

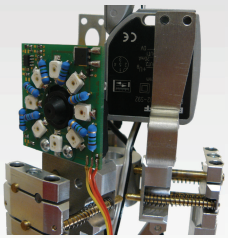
c) Electronic modules

- Electronic modules for the movement of a robot in the barrel provide synchronous control of six drives (one module for three drives). Each drive has an engine, gearbox and encoder. Other modules are used for arms collapsing and expanding, controlling the sensoric head rotation engine and finally for sensor motion within the head part. There also is an electronic module used mainly for collecting data from sensors and controling IR and laser lighting. Cameras have their own data channel.

3, Data collecting

a) Sensoric head

- Sensoric head is a swivel carrier of all sensors which are located on expanding arms. This results in approximation toward surface and better focus of the sensors (e.g. cameras). Sensoric head rotates in the range from 0 degrees to the 360 degrees with resolution of 0.6 degree. In order to set the head to the starting position, a magnet is placed on the head - that indicates the starting position of rotation.



Detail o sensoric head
left - CCD camera with IR lighting
right - triangulation laser)

b) Chosen sensors

- Different types of sensors are used on each part of sensoric head:
  - CCD camera with IR lighting
  - CCD camera with a bar laser lighting
  - Triangulation laser to measure the inside diameter of barrel
- Sensors are used for mapping of a surface inside the barrel. First CCD camera with infrared lighting is used to obtain detailed texture while the second camera with bar laser lighting is used for precise surface reconstruction. It can be evaluated for damage detection, profile depth and width measuring. Laser rangefinder is used for a precise measurement of the internal diameter (measured data are mainly used for calibration).

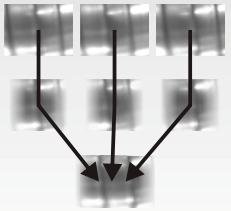
c) Diagnostic of barrel

- Process of scanning and diagnostic is fully automatic. When the robot is inserted in the barrel, scanning process can begin. The sensoric head is turned by a stepper motor in requested resolution to get sample data from all sensors. This implies that the whole measuring process is repeated by each step of the motor while the data are sending through a CAN bus to a computer. After one turn of the head, the whole device is moved forward to make new measuring process.

4, Data Processing

a) Surface texture reconstruction

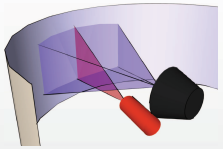
- Up to 600 images of barrel surface is obtained within one turn of sensoric head.
- These images are then folded into one image.
- All these folded images create detailed map of inner barrel.



texture reconstruction

b) Elevation profile reconstruction

- CCD camera with bar laser lighting is used for mapping elevation profile (profilometry). Laser beam hits the barrel at certain angle. The camera picks up the barrel from the perpendicular direction.
- Laser beam is then detected in the obtained image and the height map is then computed from deviation of expected position.
- Calculated values can be corrected using data from triangulation distance sensor.



elevation profile measurement

reconstructed elevation profile

c) Results evaluation

- Two elevation and texture maps captured with a certain time period can be compared (automatically or manually) to check if there are some important changes on the barrel surface since last measurement.

ISSPR 2010

Faculty of Information Technology
Brno University of Technology
Czech Republic

Josef Hájek
ihajek@fit.vutbr.cz

Aleš Marvan
imarvan@fit.vutbr.cz

Jan Váňa
ivanajan@fit.vutbr.cz