Detection and Measurement of Damages in Clean Water Pipes Based on a 3D-Light Stripe Sensor

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- Structured Light Projection Techniques
- Axial Light Stripe Sensors LSS-1
  (with Data Evaluation)
- Standard Light Stripe Sensor LSS-2
  (with Data Evaluation)
- Conclusions

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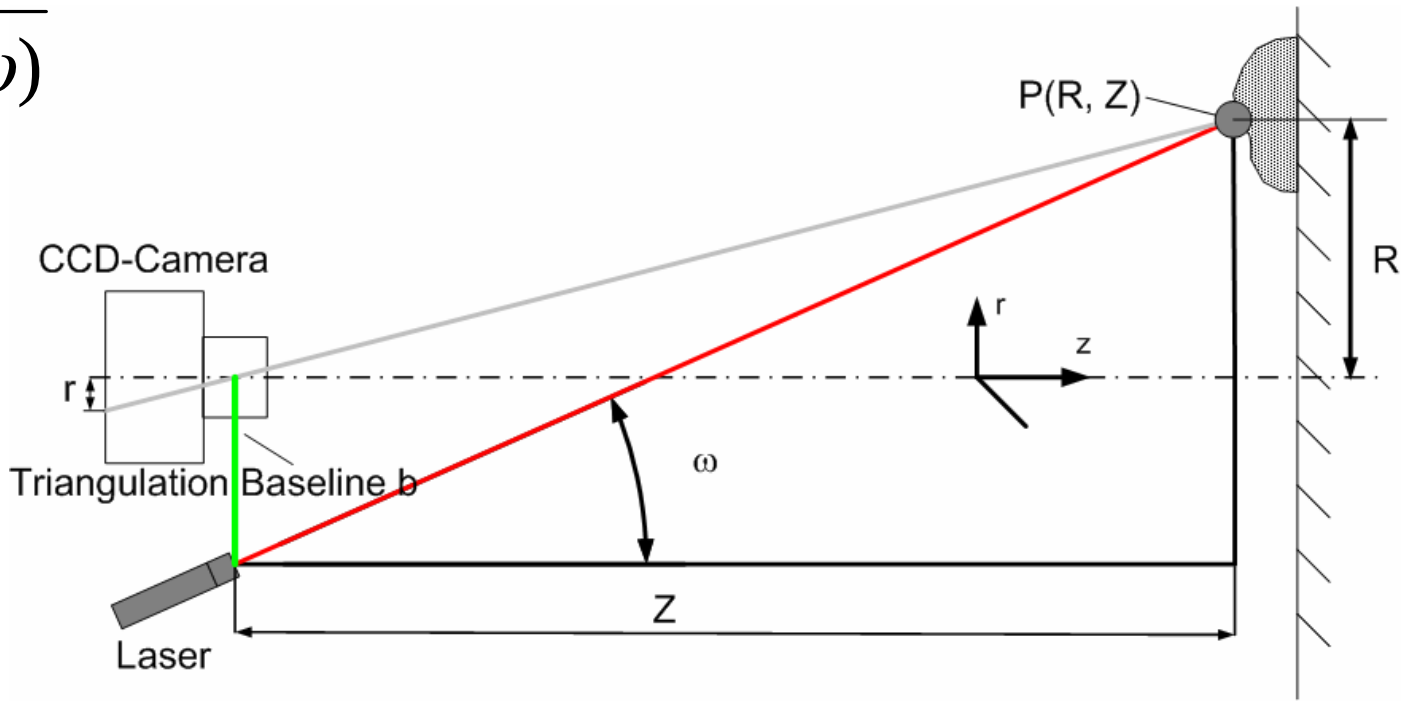
1 Structured Light Projection Techniques

1.1 Standard Light Stripe Sensor (LSS-2)

$$R = r \cdot \frac{f \cdot \tan(\omega) - b}{r - f \cdot \tan(\omega)}$$

$$Z = f \cdot \frac{r - b}{r - f \cdot \tan(\omega)}$$



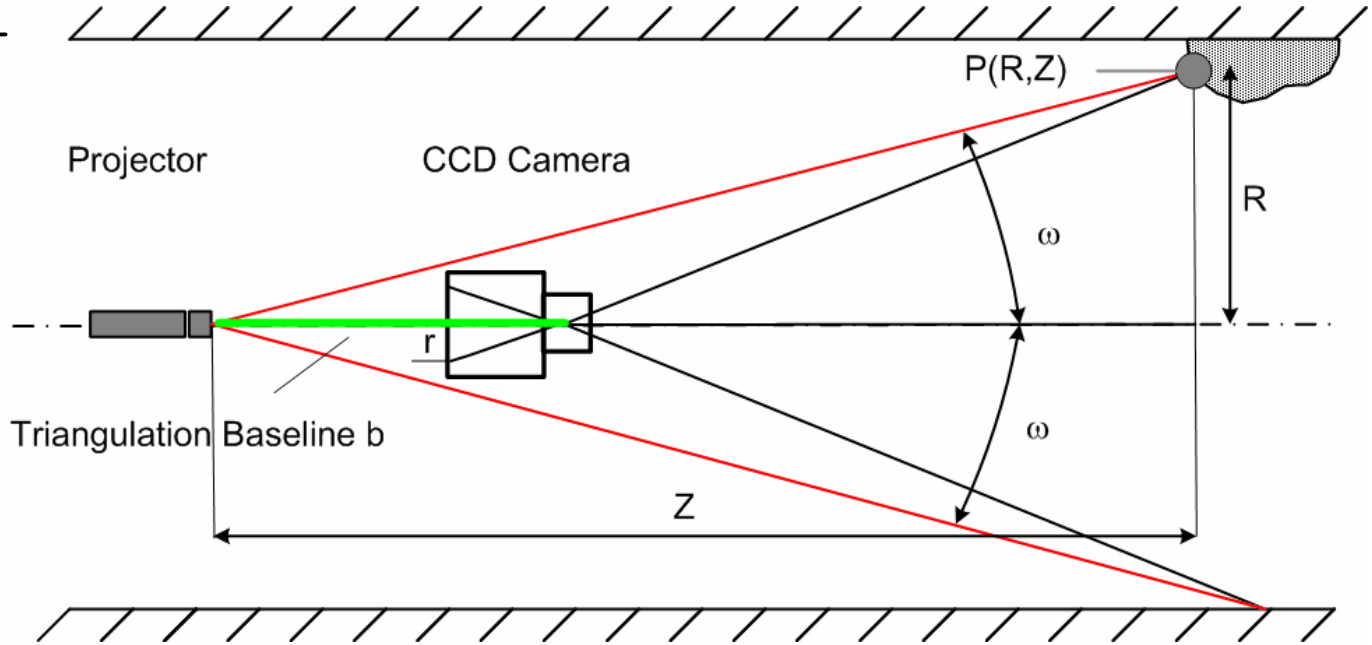
f = focal length of lens

1 Structured Light Projection Techniques

1.2 Axial Light Stripe Sensor with One Symmetric Projector, e.g. with Concentric Circles Forming Cones of Light (LSS 0)

$$R = r \cdot \frac{(b + f) \cdot \tan(\omega)}{r - f \cdot \tan(\omega)}$$

$$Z = f \cdot \frac{(b + f)}{r - f \cdot \tan(\omega)}$$



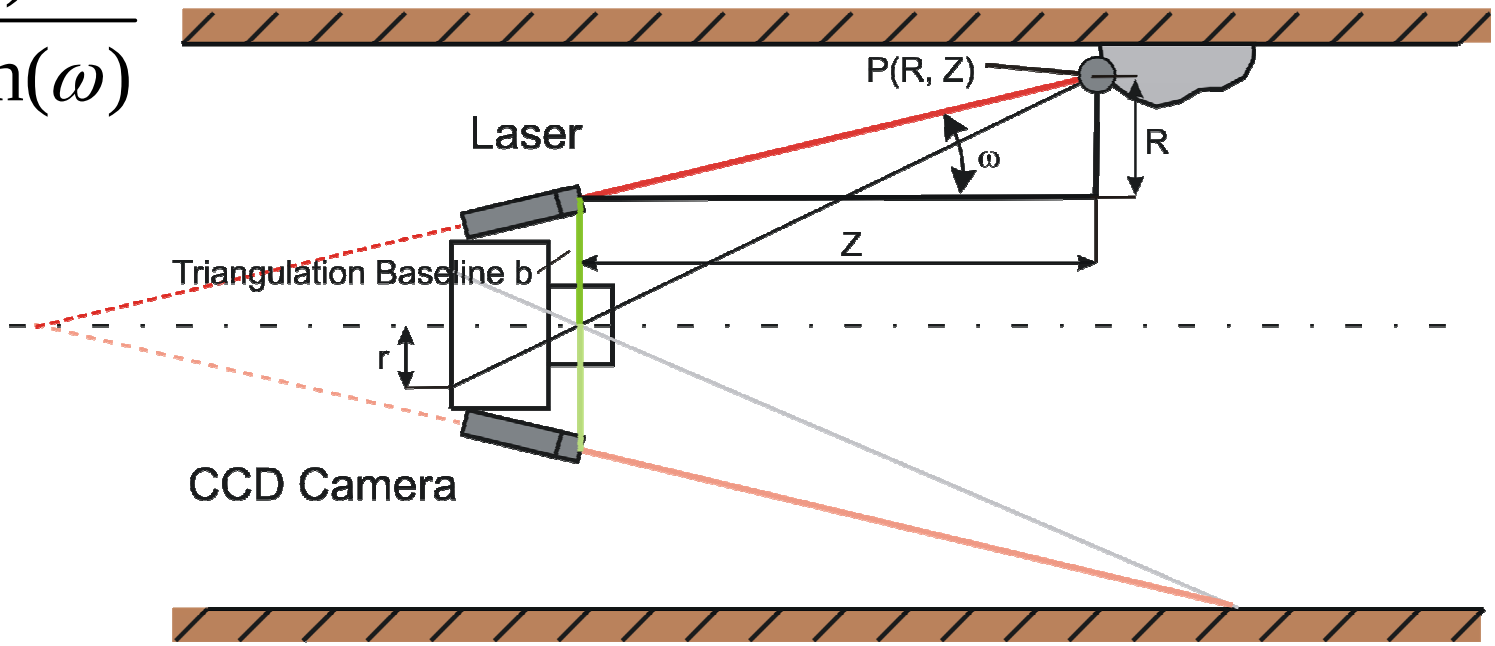
f = focal length of lens

1 Structured Light Projection Techniques

1.3 Axial Light Stripe Sensor with Several Symmetric Projectors, e.g. with 4 Line Projectors Forming Pyramids of Light (LSS-1)

$$R = f \cdot \frac{(r+b)\cdot\tan(\omega)}{r - f\cdot\tan(\omega)}$$

$$Z = f \cdot \frac{(r+b)}{r - f\cdot\tan(\omega)}$$



f = focal length of lens

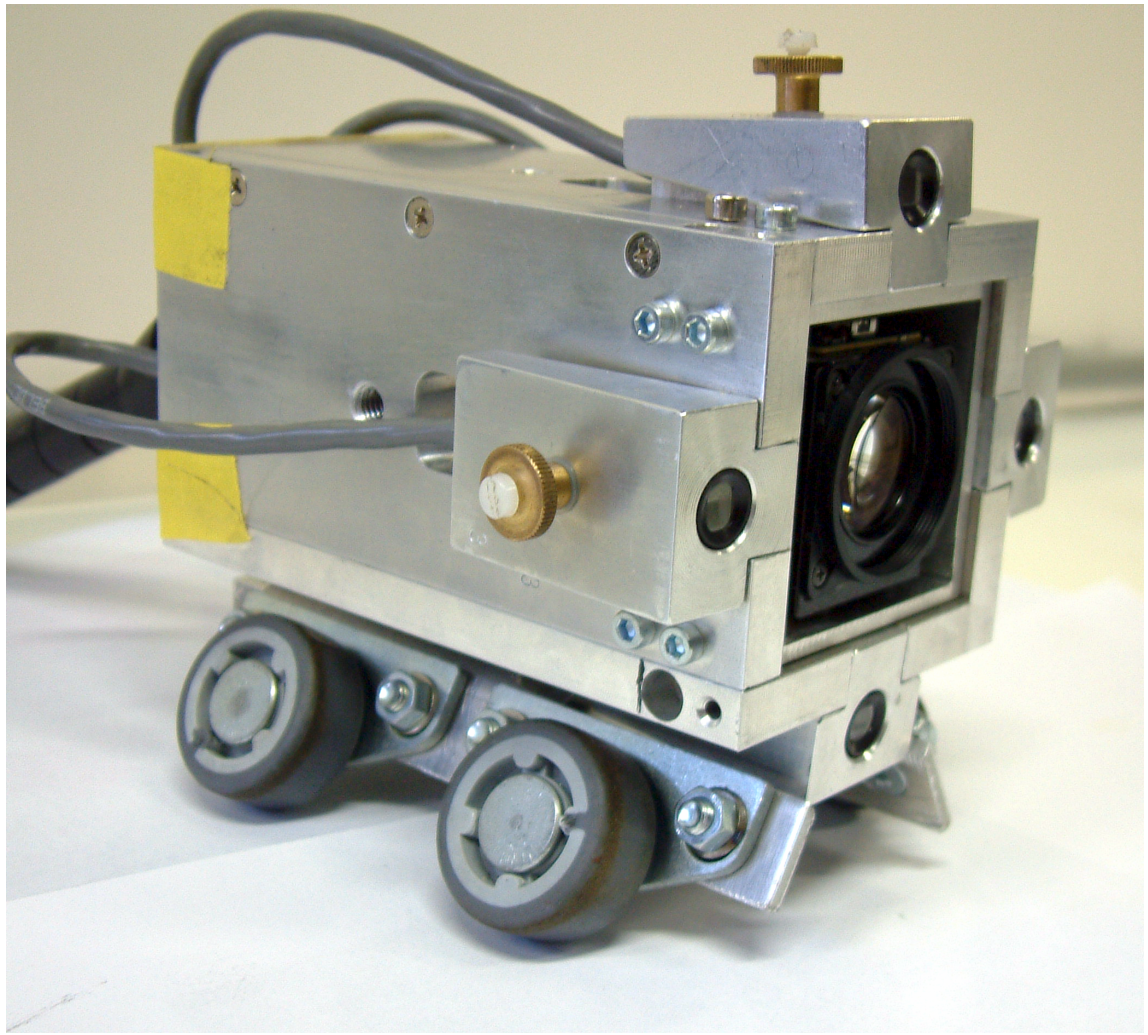
2 Axial Light Stripe Sensors LSS-1

2.1 Axial Structured Light Projection “Macro Sensor” (LSS-1a)

Application: pipe diameter
>= 150 mm

Camera: consumer
video-zoom-camera

Projectors: 4 lasers,
single line 45°,
gaussian intensity
distribution



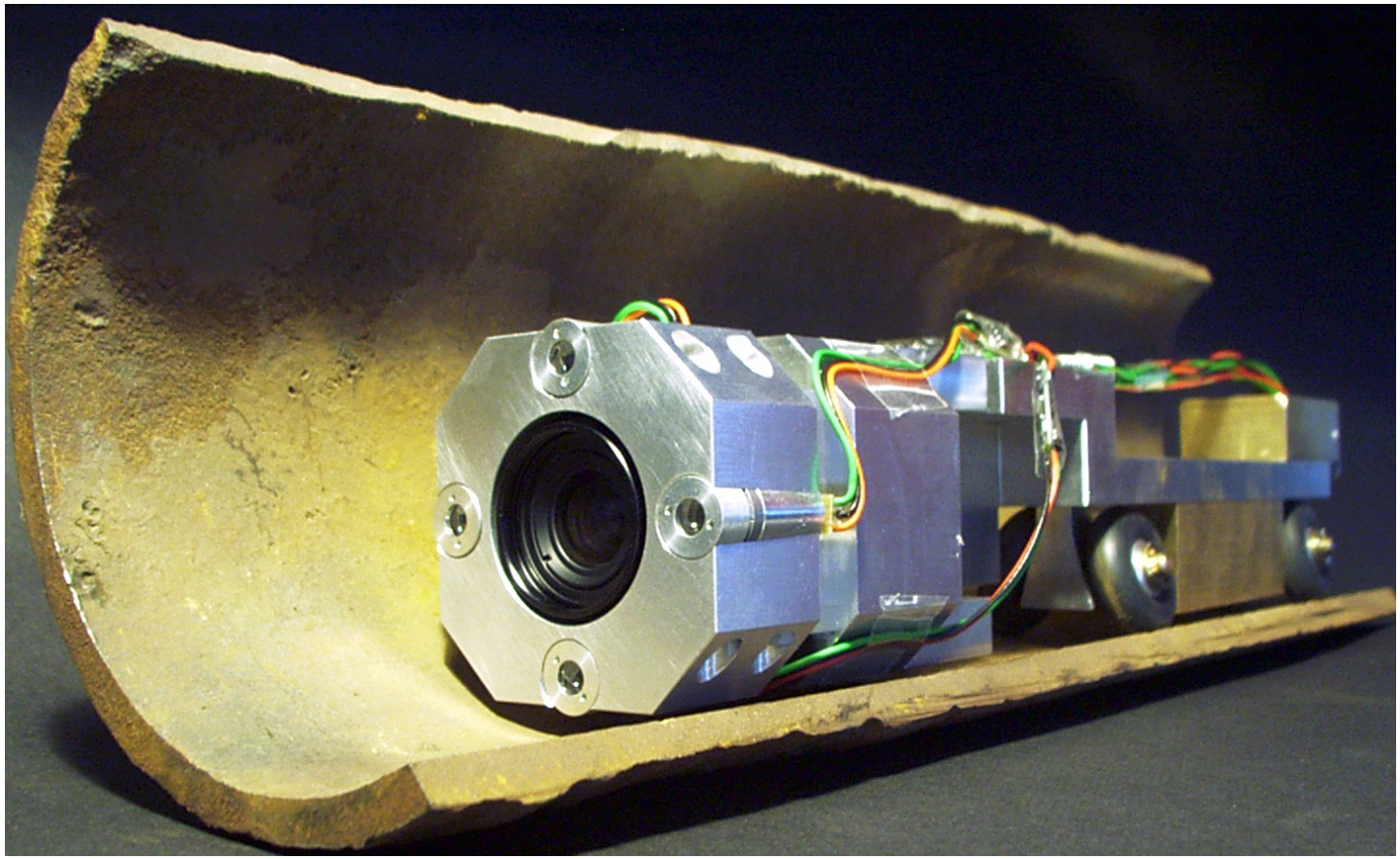
2 Axial Light Stripe Sensors LSS-1

2.2 Axial Structured Light Projection „Micro Sensor“ (LSS-1b)

Application: pipe diameter >= 100 mm

Camera: b/w, fixed focal length

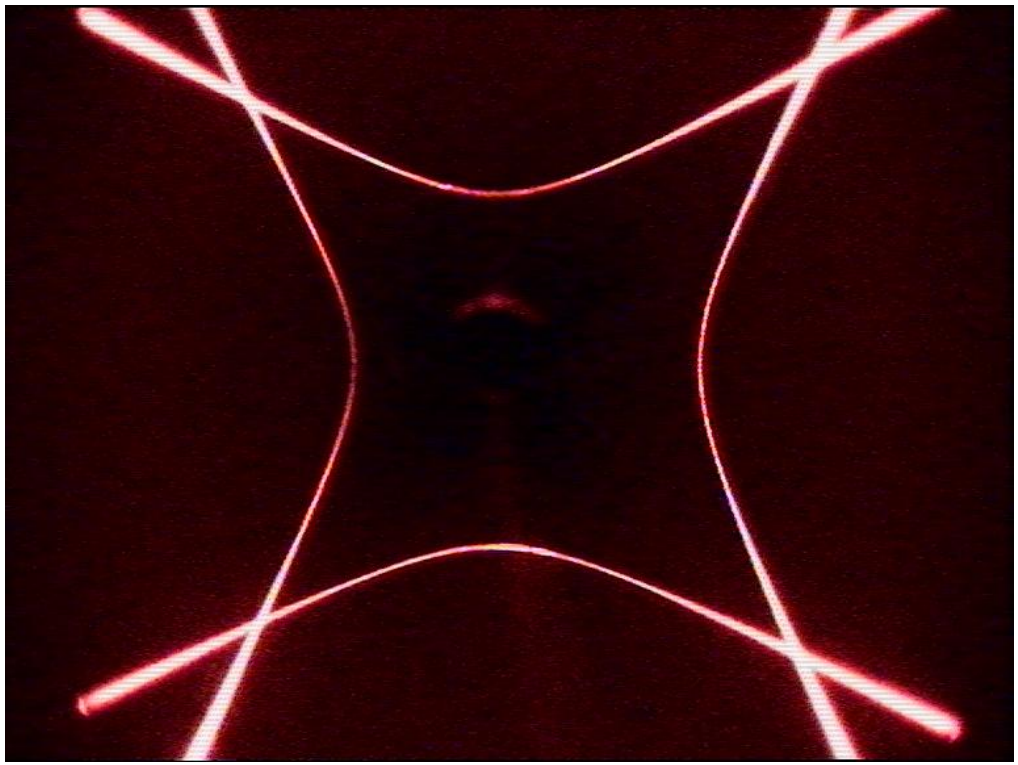
Projectors: 4 lasers, single line, gaussian intensity distribution



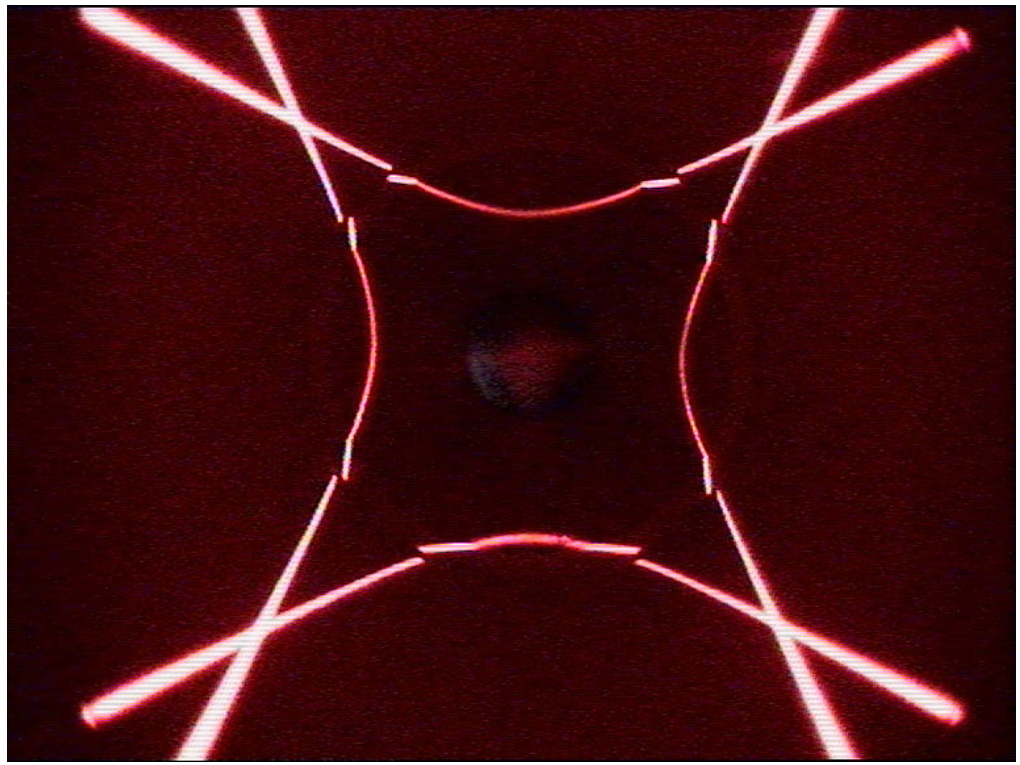
2 Axial Light Stripe Sensors LSS-1

2.3 Test Measurements with Axial Light Stripe Sensor (LSS-1a)

Homogeneous pipe

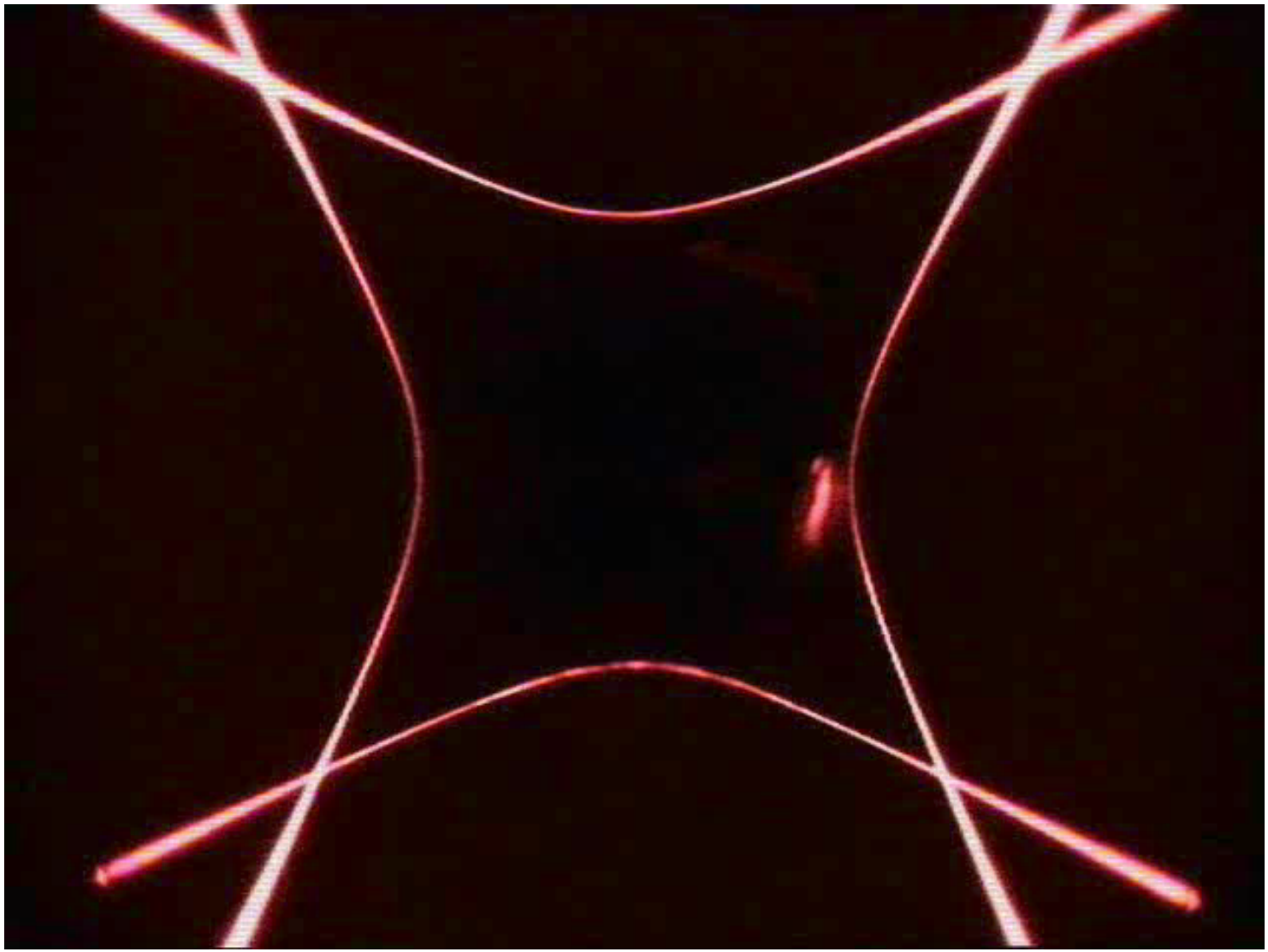


Pipe with socket



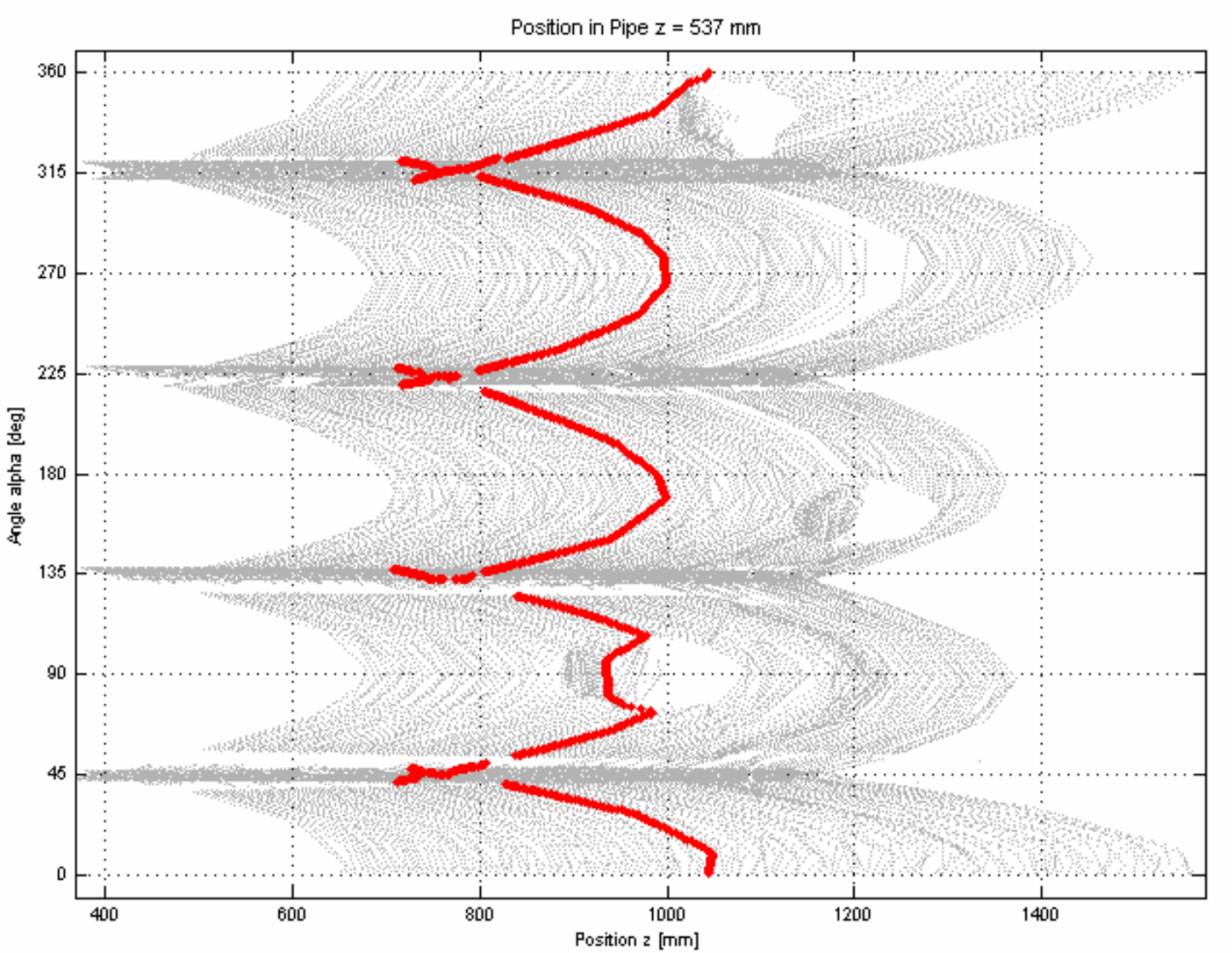
2.4 Test Measurements with Axial Light Stripe Sensor (LSS-1a)

Video



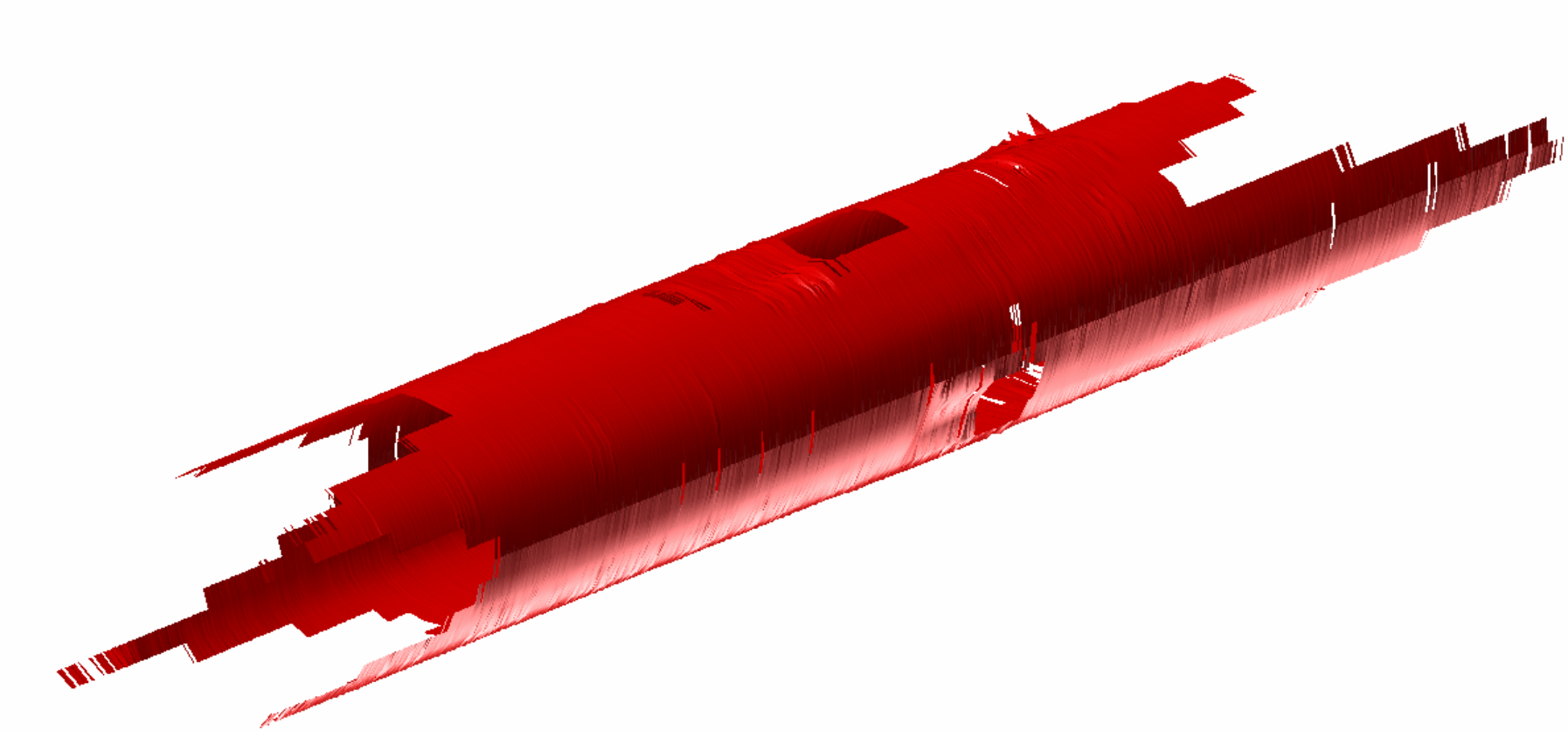
2 Axial Light Stripe Sensors LSS-1 – Data Evaluation

2.5 Example Test Measurement: All Points vs. Angle



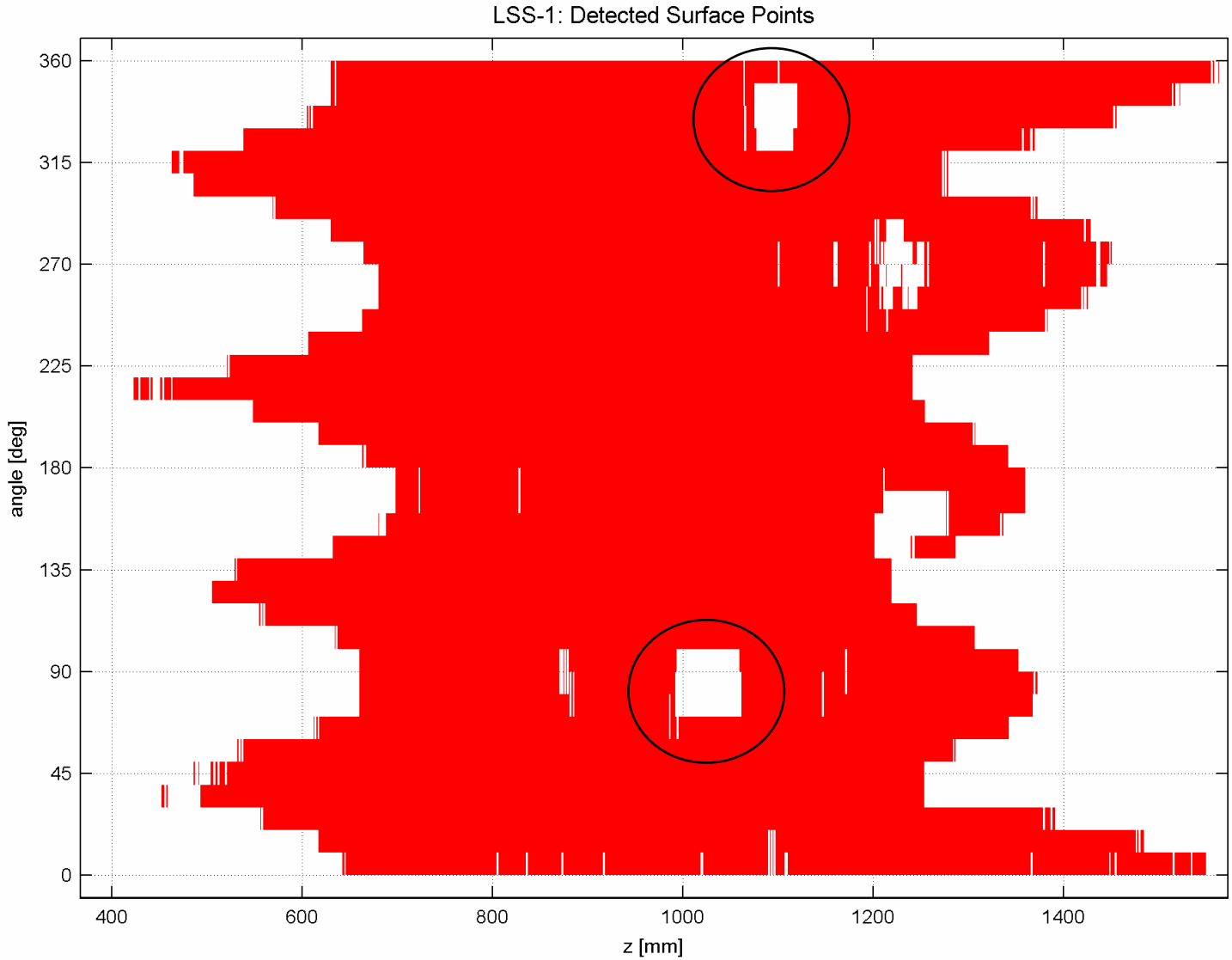
2 Axial Light Stripe Sensor LSS-1 – Data Evaluation

2.6 Generated Pipe Surface with Fuzzy Quality Assignment of Contour Points



2 Axial Light Stripe Sensor LSS-1 – Data Evaluation

2.7 Assignment Pipe Damages



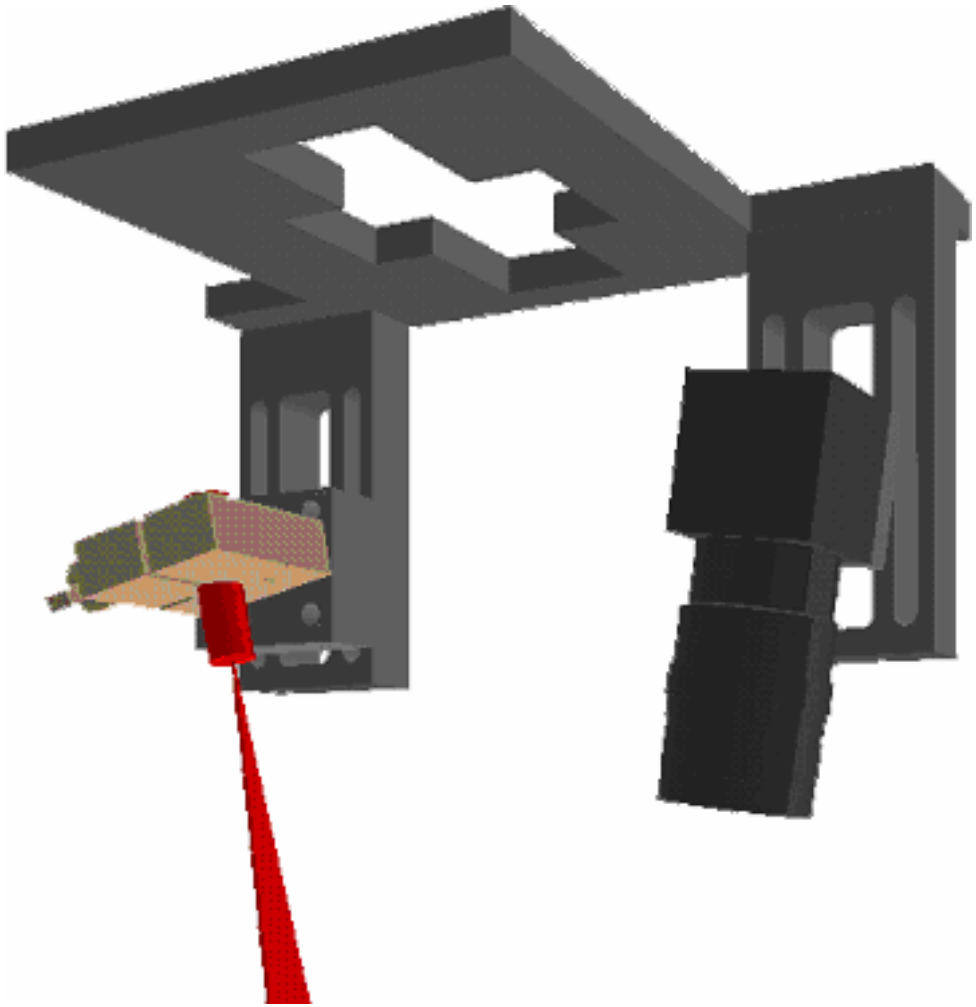
3 Standard Light Stripe Sensor LSS-2

3.1 Standard Structured Light Projection Sensor (LSS-2)

Application: accurate scanning of pipes

Camera: b/w,
fixed focal length

Projectors: 4 lasers
single line 45°,
equal intensity distribution

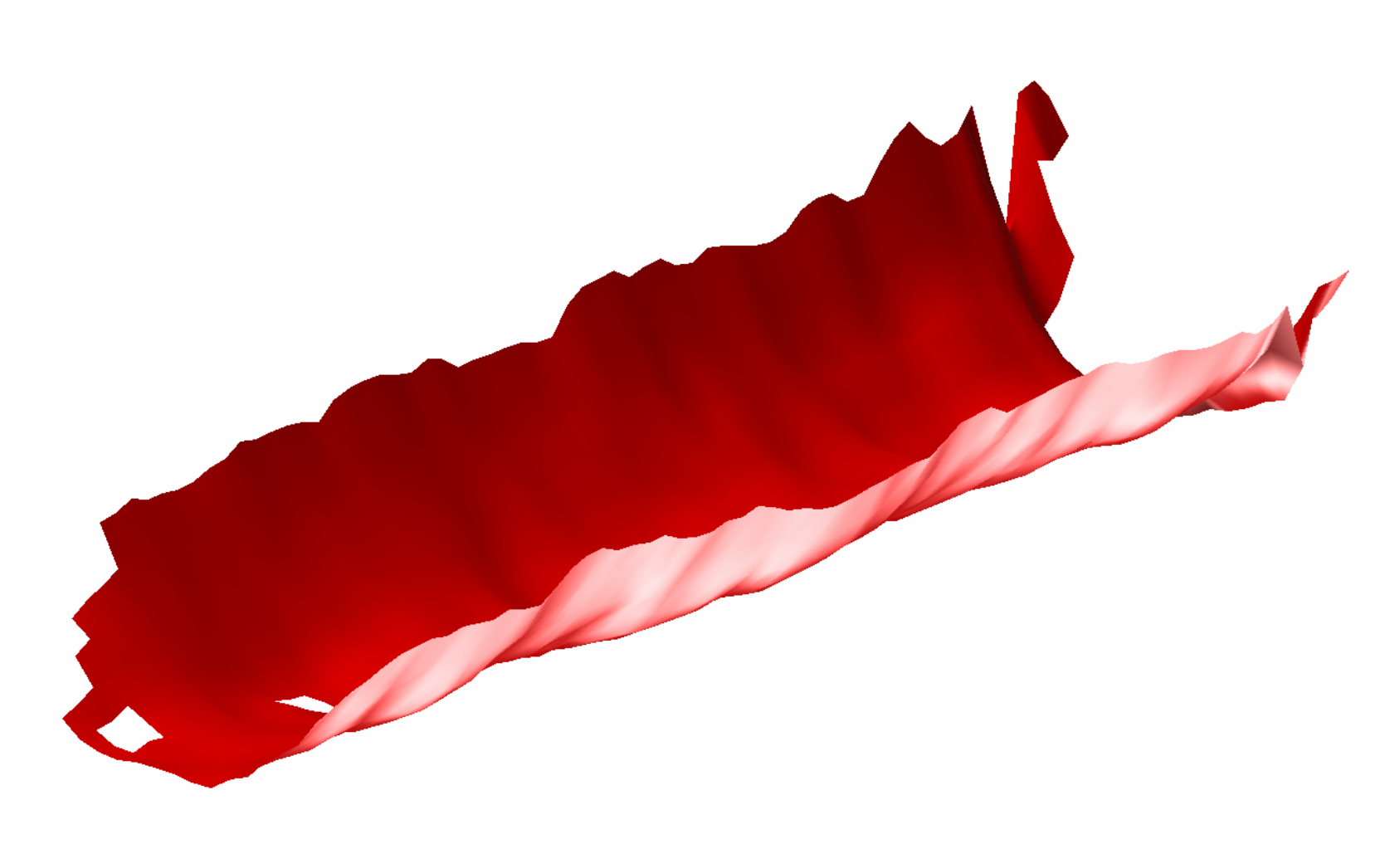


3 Standard Light Stripe Sensor LSS-2

3.2 Old Clean Water Test Pipes

3 Standard Light Stripe Sensor LSS-2 – Data Evaluation

3.3 Generated Surface on discrete X/Y Grid (Pipe3)



4 Conclusions

- **Damages in Clean Water Pipes Very Well Detectable and Measurable with a 3D-Light Stripe Sensor**

- **Axial Light Stripe Sensor**
  - + Only one camera
  - + One image to process
  - + Integration in standard pan/tilt unit possible
  - - Shadowing effects
  - - Difficult image-processing and line detection
  - - Inaccurate due to mechanical construction (resulting large range of laser projection)

- **Standard Light Stripe Sensor**
  - + Image processing with less computational effort
  - + High accuracy
  - + Very wide range of operation (small and large pipes)
  - - 4 Cameras
  - - 4 Images to handle