In Situ Monitoring for Laser Powder Bed Fusion Using Digital Fringe Projection Technique

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System Setup

Camera Used for Measurements Shown Here

SLR Cameras

Projector

Powder Bed

Laser Power Bed Fusion Machine (EWI, Columbus, OH)

* Note: Some parts are hidden for visualization purpose.
Digital Fringe Projection

A digital fringe projection system consists of

- A digital projector
- A digital camera
- A computer

Sinusoidal fringes projected on a white cylindrical part

Reconstructed 3D surface profile
Digital Fringe Projection & Machine Vision Procedure

- Nonlinearity correction
- Phase shifting algorithm
- Phase unwarpping
- Conversion from phase to height
- Filtering
- Height map

Legendre polynomial fitting (up to third order)
Picture of the Powder Surface Under Monitoring

1. Picture taken during Laser Power Bed Fusion process (EWI, Columbus, OH)
2. Parts fabricated by Laser Power Bed Fusion Machine (EWI, Columbus, OH)
Sequence of Measurements Taken in One Build Cycle

Data to be shown
- Examples of measurements within build cycles
- Measurement 2 for cycles 1-30
- Tracking average heights over build cycles

One layer of powder is dispensed.

Laser fuses powder

z stage drops 40 μm. Wiper blade returns.

New layer of powder is dispensed.

Meas. 1
Meas. 2
Meas. 3
Build Cycle 1
Within each cycle, the same region in the height map 2 and map 3 are used to calculate the average height difference.
Build Platform Drop Tracking

Layer No.

Build Platform Drop

h (μm)

Layer No.
Build Cycle 7
Sequence of Measurements Taken in One Build Cycle

Data to be shown

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One layer of powder is dispensed.

Wiper blade

Laser fuses powder

z stage drops 40 μm. Wiper blade returns.

New layer of powder is dispensed.

Meas. 1

Meas. 2

Meas. 3
Cross Section Tracing on Cycle 1

- Height map
- Vertical line profile
- Horizontal line profile
Profile of Cross Section at Cycle 7
Tracking Height Changes in Powder

1. Track the height of the unfused powder
2. Track the height of fused powder
3. Compare 1 and 2 for the metal-powder height difference

Height map of laser fusion powder bed
3°C will cause chamber grow 40 μm.

Total about 3 hours
Tracking the Absolute Height of Fused and Unfused Area

Measurement 2

Height Difference Between Metal And Powder (h1-h0)

Layer No

Δh (μm)
Future Work

• Investigate any potential drift of the measurement system relative to the build area.

• Optimize system design to increase the resolution and accuracy.

• Increase the speed of measurement.

Thank you! Questions?

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