5G Implementation in Defect Inspection Facility

5G Network Foundation Course Finals

Inspection Facility

- *Focus in Automotive parts*
- *Have 5 Inspection Line*

Scenario Information: What we working on?
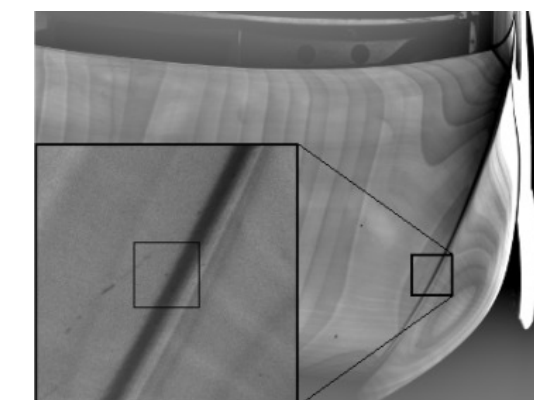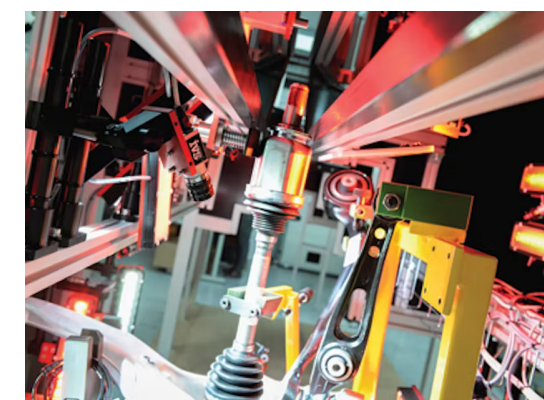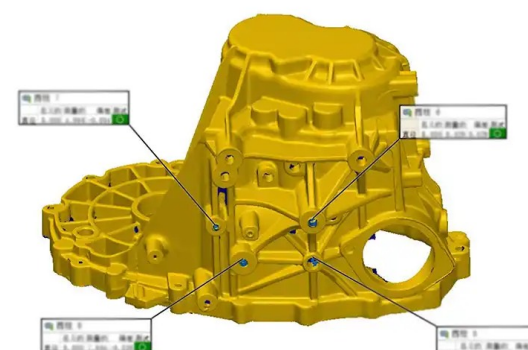
Parts to be Inspect

| Piston | Gearbox Housing | Suspension Rods | Body Panel | Wheel Rim |

Inspection Requirements

Detection Surface				
6 (4 in High Res)	6 (2 in High Res)	8 (3 in High Res)	4 (1 in High Res)	6 in Normal Res
Minimum Defect Size				
1 mm/pixel	1 mm/pixel	1 mm/pixel	1 mm/pixel	3 mm/pixel

Detection Details

- High resolution indicates 1920x1080 / Normal resolution is 800x600 (pixel).
- Camera record in 30 Frame per Second (fps) is capable to detect defects accurately.
- All the recordings and detection results have to sent to central database for QC reports.

Project Objectives: Trade-offs

- **Design and validate URLLC network slices** to meet sub-10 ms latency for high-precision streams.

- **Integrate Multi-Access Edge Computing (MEC)** nodes at the factory floor to offload inference and minimize core-network latency

- **Benchmark open-source 5G stacks** under mixed URLLC/eMBB traffic replicating our five inspection lines.

Defect-Detection Performance Requirements

Default 0.32

Bitrate (bps) = Width (px) × Height (px) × Frame rate (fps) × BPP

Critical inspection faces (1920x1080)

- End-to-end latency ≤ 10 ms

- Packet-loss rate ≤ 10^{-5}

$1920 \times 1080 \times 30 \times 0.32 \approx 19{,}907{,}712$ bps ≈ 19.9 Mbps

Non-Critical inspection faces (800x600)

- Support ≥ N simultaneous streams

- Average one-way latency ≤ 50 ms

$800 \times 600 \times 30 \times 0.32 \approx 4{,}608{,}000$ bps ≈ 4.6 Mbps

Mapping to 5G QoS

URLLC slice

- Latency Budget: ≤ 10 ms

- Reliability ≥ 99.999% (packet-loss ≤ 10^{-5})

- Guaranteed Bitrate

eMBB slice

- Throughput 5 Mbps per 600p stream

- Latency Target: ≤ 50 ms

- lower than URLLC but above standard best-effort