Using Laser Projectors for Augmented Reality

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Outline

• Applications
  – Quality assurance
  – Maintenance

• Problems
  – 1) Projecting on arbitrary surfaces
  – 2) Accuracy and sources of error
  – 3) Where to mount the projector

• Current system
  – Setup
  – Accuracy evaluation

• Summary
Applications 1: Quality Assurance in Series Production

Inspection of welding points on white bodies

- E.g car doors
- Each 25th door
- Varying points (due to previous quality)
- Different methods of inspection
  - e.g viewing, ultrasound, destructive testing
Applications 2: Maintenance Support

• Display of the maintenance workflow

• Requirements
  – Mobile
  – Quick and easy set-up
Problems

• 1) Projection on arbitrary surfaces
• 2) Accuracy and sources of error
• 3) Where to mount the projector
Problem: 1) Projection on Arbitrary Surfaces

• General
  – Requires presence of a surface
  – Public display

• Photometric and Optical
  – Bright illuminated workplaces
  – Metallic raw objects (e.g. white body)
    • reflecting light mainly in the specular direction
    • minimal amount of light is reflected omnidirectional towards arbitrary viewer positions

• Geometric issues
  – Deep dents, significant surface structure
  – Requires a pre-distorted projection
Problem: 1) Projection on Arbitrary Surfaces
Hybride Display

where-to-act

what-to-do
Problem: 2) Accuracy and Sources of Error

• Accuracy depends on distance between projector and object rather than user and object

• E.g. 1 cm Accuracy required
  – projection distance 2 meters -> requires 5 mrad ≈ 0.3°

• Sources of error
  – Intrinsic calibration
  – Extrinsic calibration (tracking)
    • use inside-out (better rotation)
    • instead of outside-in (better translation)
  – Cheap laser scanners
Problem: 3) Where to Mount the Projector

• Occlusion
  – By user (standing in the line of projection)
  – By object itself (protruding parts)

• Solutions
  – Optimized projector placement (next Slide)
  – Smart projection (not yet solved)
Problem: 3) Where to Mount the Projector

• Head/shoulder-mounted projector
  – Unlimited field of projection
  – No occlusion problems
  – Has to be light-weight
    • Accurate scanners are heavy
    • Needs accurate and fast tracking
  – Acceptability

• Room mounted
  – Slow but robust tracking
  – No weight limitations
  – Limited field of projection
  – Occlusion problem
  – Potentially expensive
Current System

• Tripod mounted: balances some tradeoffs

• Still movable - reconfigurable
  – does not suffer from limited range of a room-mounted setup

• More weight possible
  – scanning
  – extra sensing hardware

• No fast tracking required
Current System

- **Inside-out tracking**
  - Theoretically better than outside-in

- **Fish-eye camera**
  - Tracked object always in Fiels of view
Current System: Accuracy Evaluation

Outside-In Tracking vs. Inside-Out Tracking
Current System: Accuracy Evaluation
Current System: Accuracy Evaluation

Outside-In Tracking
Current System: Accuracy Evaluation

Inside-Out Tracking
Current System: Accuracy Evaluation

Extrema of the Projection Field

Error: 5 mrad ≈ 0.3°
Current System: Accuracy Evaluation

• Conclusion:
  • In theory
    • Inside-Out should outperform the Outside-In
  • In practice
    • having a large tracking area...

• A different setup will look different.... come and see it next door