# Overview of Computer Vision Techniques in Robotized Wire Harness Assembly: Current State and Future Opportunities

Hao Wang[1], Omkar Salunkhe[1], Walter Quadrini[2], Dan Lämkull[3], Fredrik Ore[4], Björn Johansson[1], Johan Stahre[1]

1 CHALMERS UNIVERSITY OF TECHNOLOGY
2 POLITECNICO MILANO 1863
3 VOLVO
4 SCANIA

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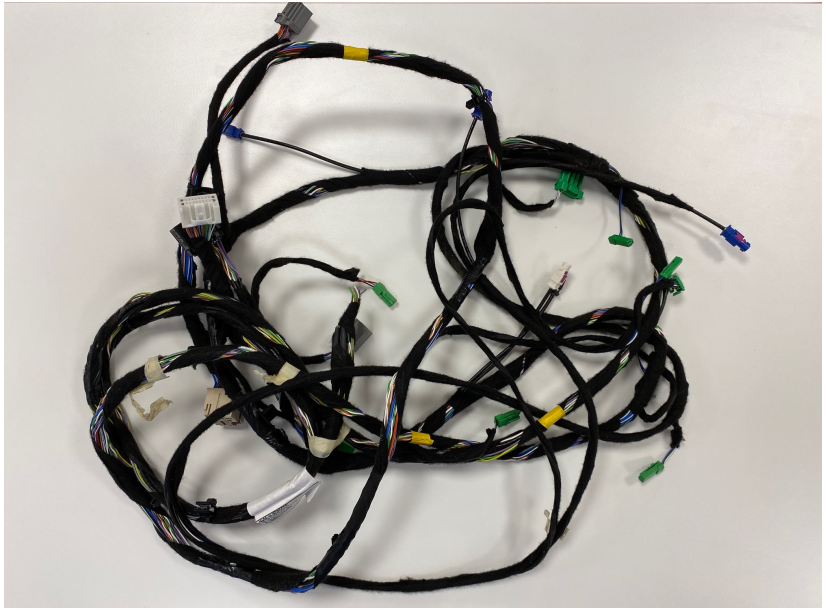
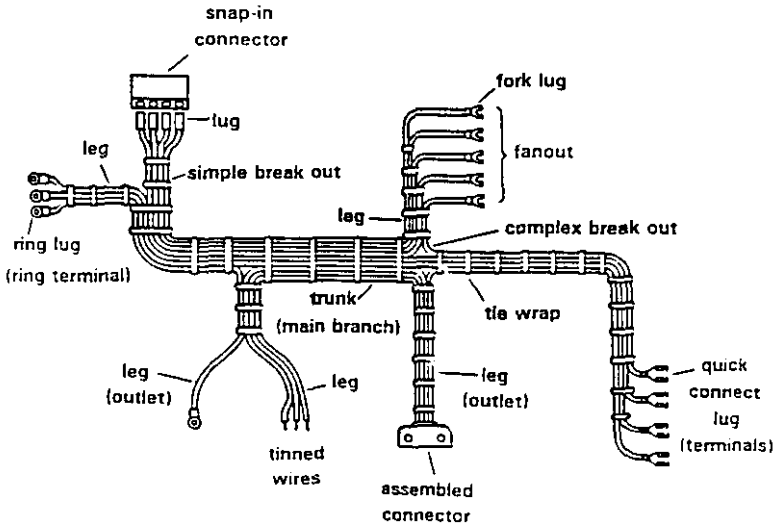
# Wire harnesses





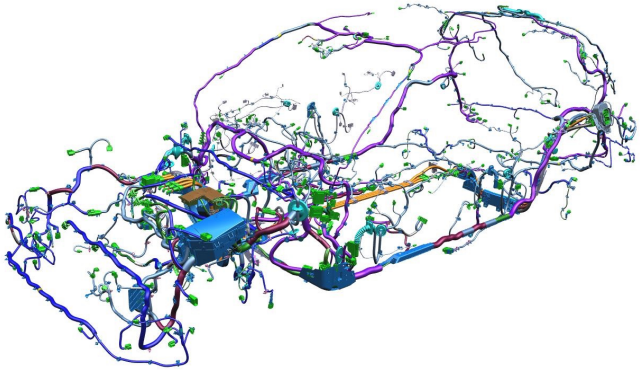

Source: Aguirre and Raucent (1994)

**A bundle of routed cables with various components in a tree-like structure**

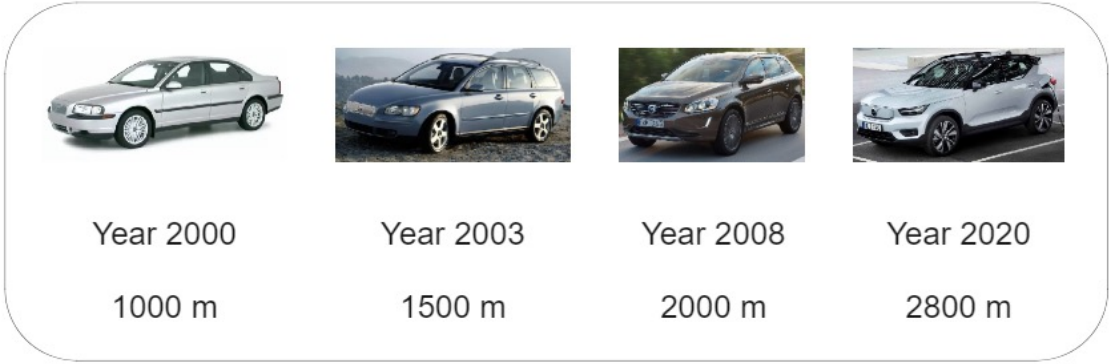


Aguirre, E., Raucent, B., 1994. Economic comparison of wire harness assembly systems. Journal of Manufacturing Systems 13, 276–288.doi: 10.1016/0278-6125(94)90035-3

# Wire harness assembly



(Images provided by Volvo Car Corporation)




(Images provided by Volvo Car Corporation)

**Essential infrastructure**

**Increasing usage**

**Electrification**

**Critical to guarantee the safety and quality of the assembly**

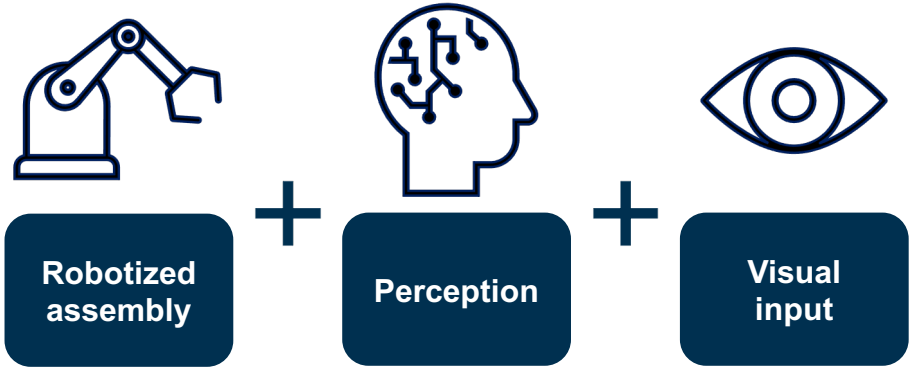
# Wire harness assembly

## Current assembly operations

- Manual
- Skill-demanding

## Problem

- Quality
- Productivity
- Safety
- Ergonomics



# Methodology

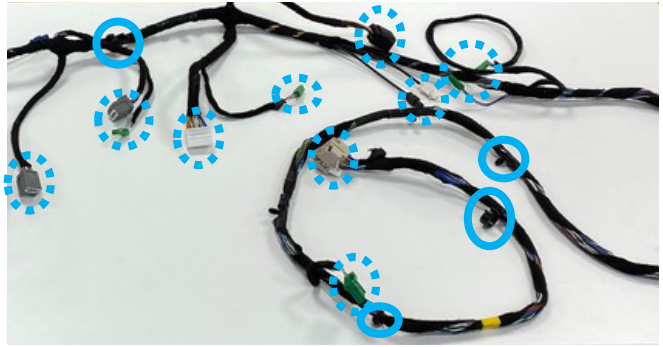
**Literature search**

- Scopus
- (wir* OR cabl*) AND (harness* OR bundl*) AND assembl*

**Literature selection**

- Final assembly of wire harnesses onto other products
- Proposing vision systems for the robotized assembly
- Not review and conference review
- English

# Component manipulation



**Clamp insertion**

- Clamp (cover) pose estimation

**Connector mating**

- Connector detection & pose estimation
- Vision-guided mating
- Fault detection

Table 1. Vision systems in articles for manipulation on components of wire harnesses.

| Component | Article | Type of cameras | Location of cameras | Number of cameras |
|---|---|---|---|---|
| Clamp | [13] | - | Hand-eye | 4 |
| | [7, 8] | CCD cameras | Global-fixed + Hand-eye | 10 fixed + 6 on end-effectors |
| | [9] | Point Grey Firefly MV | Hand-eye | 1 |
| Connector | [27] | MC1362, Mikrotron | Global-fixed | 1 |
| | [30] | RealSense D435, Intel | Hand-eye | 1 |
| | [32] | Industrial cameras | Global-fixed + Hand-eye | 1 fixed + 2 on robot arms |
| | [3] | In-Sight 5100 | Global-fixed | 1 |
| | [26] | CCD cameras | Global-fixed | 2 |
| | [2] | CCD cameras | Global-fixed | 2 |
| | [25] | FL2G-13S2C-C, PGR | Hand-eye | 1 |

(Reference numbers are the same as those in the paper)

# Component manipulation

## Clamp insertion

- Clamp (cover) pose estimation
- Additional clamp covers were attached
- Rule-based computer vision
- Facilitate detection and manipulation
- Occupy space and add operations
- New clamp designs are desired

## Connector mating

- Connector detection and mating monitoring
- Mainly 2D vision-based detection
- Mainly rule-based computer vision
- 2D data is easier to process than 3D data
- 3D info (position, orientation) is required
- Capture and process 3D data

- Learning-based algorithms + 2D & 3D vision needs to be explored
- Practicality and reliability need to be evaluated in actual scenarios

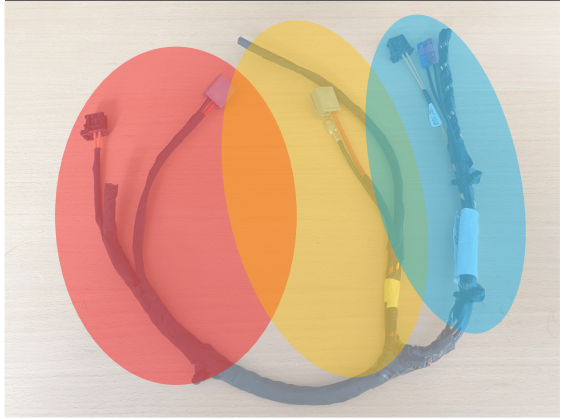
# Structure perception

Table 2. Vision systems in articles for perceiving the structure of a wire harness.

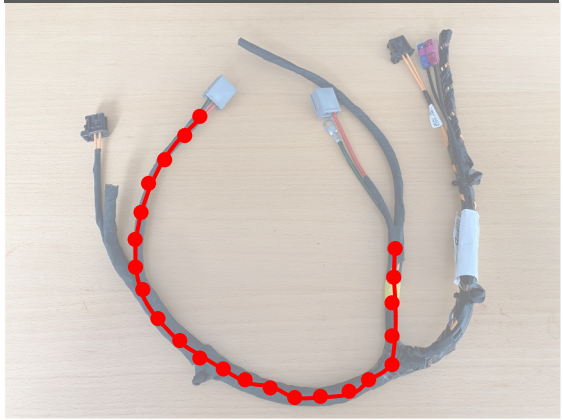
| Article | Purpose | Type of cameras | Location of cameras | Number of cameras |
|---|---|---|---|---|
| [12] | Interpretable classification | RealSense D435, Intel | Global-fixed | 1 |
| [19] | 3D profile extraction | Helios Time-of-Flight camera | Hand-eye | 1 |
| [4] | Visual recognition | RGB-D | - | - |

(Reference numbers are the same as those in the paper)

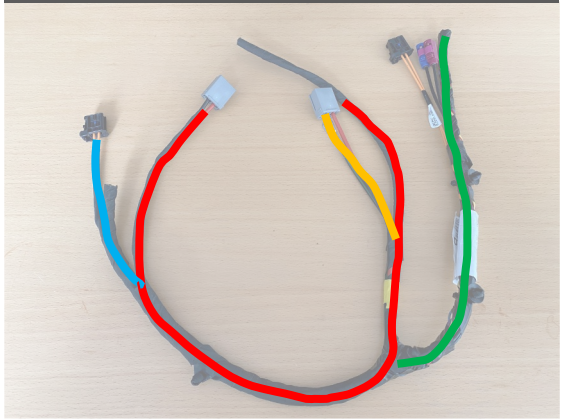
Interpretable branch classification



3D profile extraction



Visual recognition and segmentation



RGB-D data + learning-based algorithm on other components

# Conclusion

- Previous studies proposed various vision-based solutions for:
  - Manipulation of different wire harness components
  - Perception of the wire harness structure
- Future research opportunities:
  - Developing new learning-based computer vision algorithms to exploit 3D information
  - Evaluating the practicality and reliability of vision systems in actual production to promote practical applications
  - Exploring new product designs of wire harnesses to enable a more efficient visual perception and robotic manipulation

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haowang@chalmers.se

# Thank you!