

# AI Applications 워크샵 – 생활속의 인공지능

June 3, 2016



## 증강현실 과 지식 그래프 융합을 통한 복잡한 기계의 유지 보수

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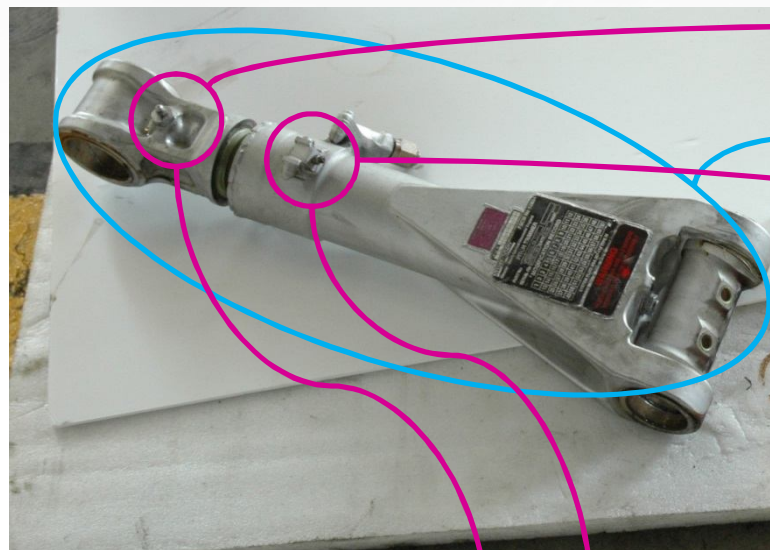
# Contents

- Introduction
- System Description
  - Augmented Reality (AR)
  - Knowledge Graph
  - A Unified Framework for AR and Knowledge
    - ✓ UI/UX
    - ✓ Context Management
    - ✓ Integration
- A Case Study of Aircraft Maintenance Work
  - Video Demo
- Conclusion

# Introduction

- Given the increasingly complex nature of maintenance operations in the aerospace field, handling huge numbers of technical documents for maintenance has become a complicated and tedious process

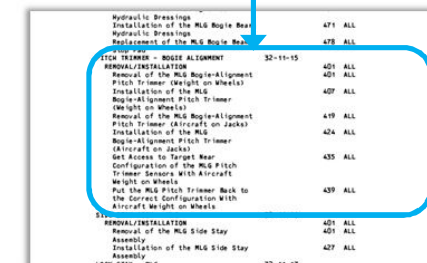
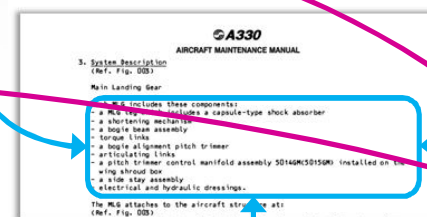
## Manuals used for aircraft maintenance



Instruction -

6. Make sure that the bleed screws (23) and (25) are closed.

### Aircraft Maintenance Manual



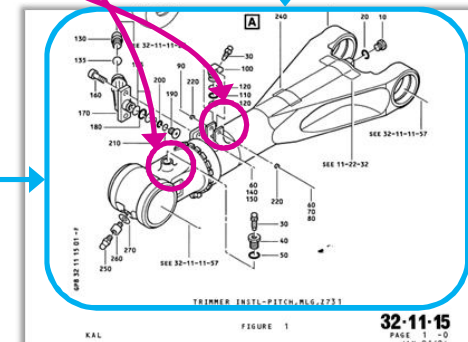
### Component Maintenance Manual

### Landing Gear

#### └ Gears and Doors

#### └ Main Landing Gear

#### └ Bogie alignment pitch trimmer



### Illustrated Parts Catalog

# Motivation

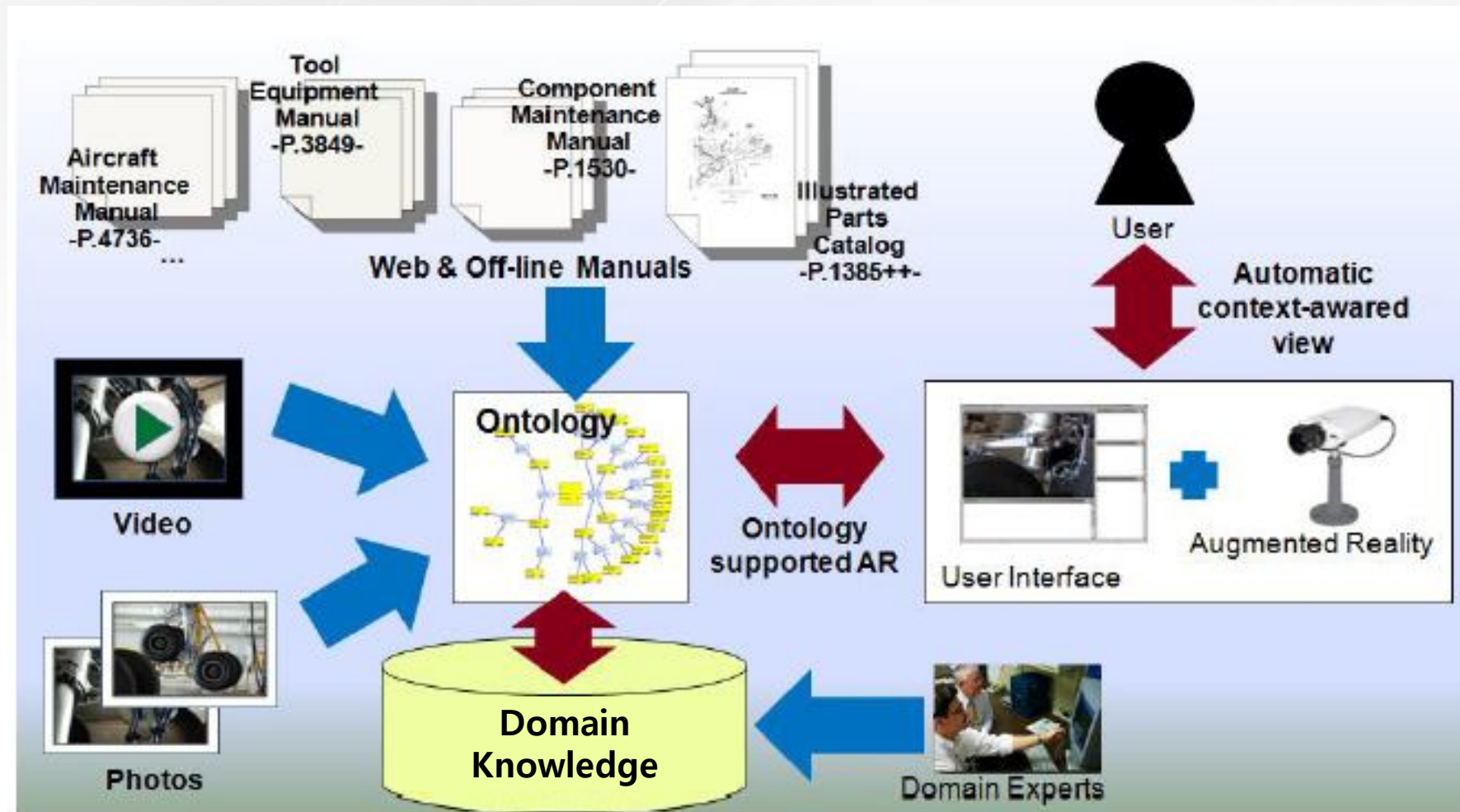
- To enhance Aircraft maintenance and Training effectiveness
  - How to present the information and task instructions clearly in the context of the actual aircraft
    - ✓ Effective visualization of the information for technicians

**Augmented Reality** is used for the visualization

- Determining what information is relevant to a specific aircraft maintenance
  - ✓ Providing useful information for every step of an instruction

**Knowledge** is used for what information is needed for implementing a specific instruction from various manual resources such as AMM, IPC and TEM

# System Overview



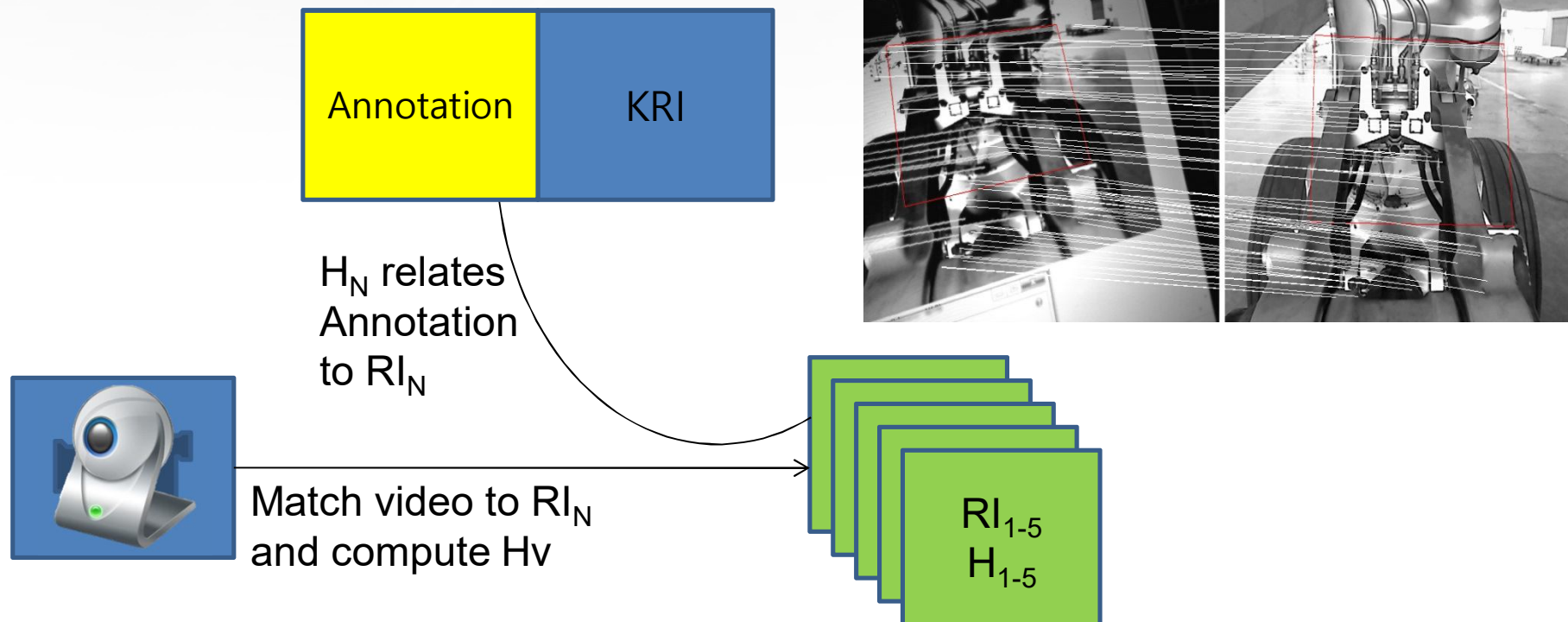


# AR(Augmented Reality)

- Augmented Reality is a compelling means for how to present and interact with information in context
- Developed the vision-based recognition, tracking and annotations methods needed to align annotations with camera image
- Represented improved computer vision achievements for real-time and robust performance in the very challenging conditions posed by aircraft settings
- As in the case of all other object recognition techniques, strong light variations affect the object recognition performance of the system. On-site environments change frequently according to weather conditions and whether the hanger door is open.

# AR(Augmented Reality) Module

- AR module is told what KRI (Key reference images) image and annotation to process (by KBS module)
- AR module receives live video from the camera and attempts to match live video to all RIs(reference images) associated with KRI
- When a match is obtained to a  $RI_N$ , its homography,  $H_N$  is used to relate the DB KRI annotation to the video image



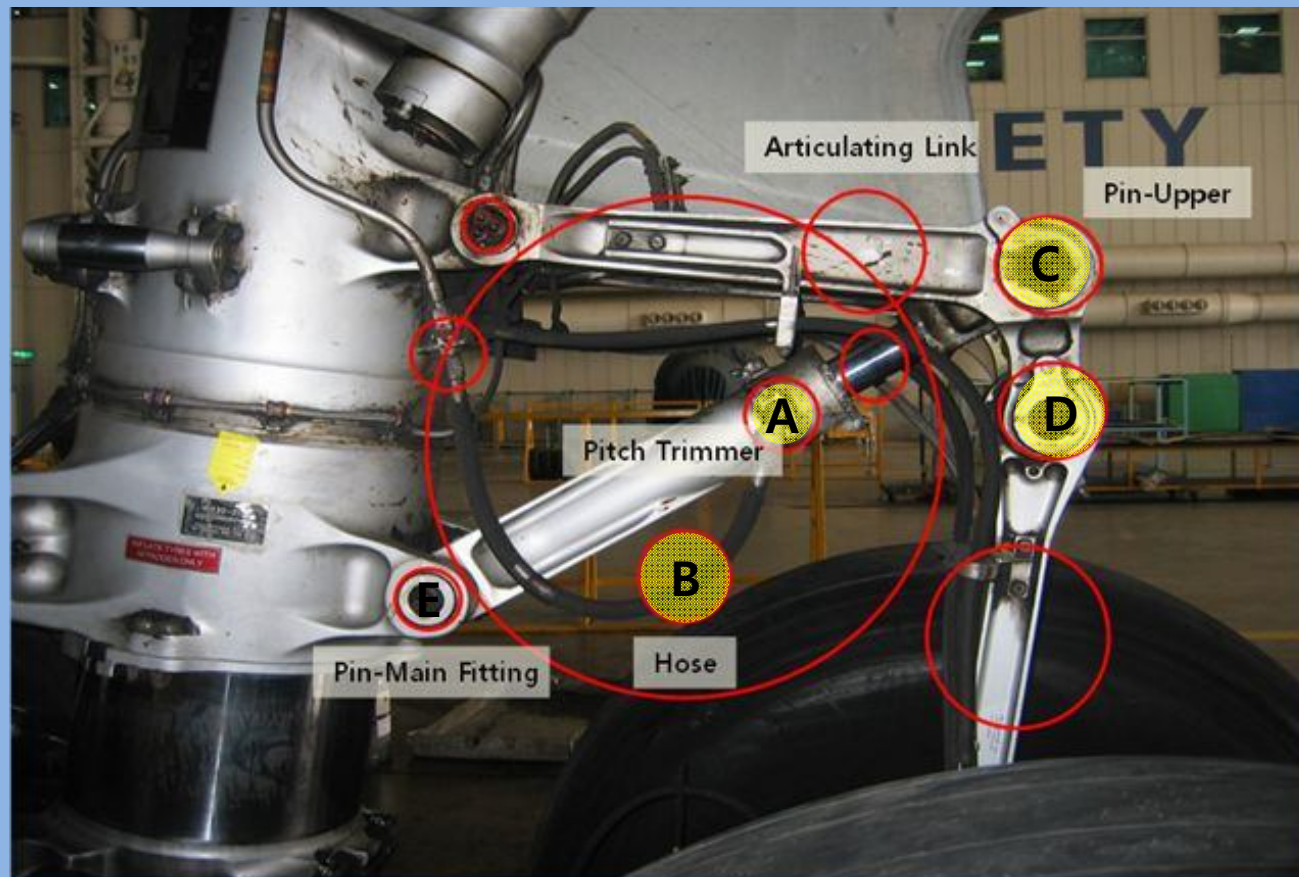
# Knowledge Graph – Model Building

- Knowledge Graph are a means of identifying relevant and unambiguous information related to a task and its context
  - ✓ Ontology modeling for aircraft maintenance
  - ✓ Automatically generated ontology instances of technical manuals
  - ✓ Unified and summarized view for integrating maintenance resources such as video, photos, links, figures, and other resources with the manuals
  - ✓ Integrating data management tools such as the video annotation tool, ontology population tool, and AR animation tool



## A330 Landing Gear Maintenance Training System

### VIEW



### TASK INFORMATION



TASK 32-11-15-000-801  
Removal of the MLG Bogie-Alignment  
Pitch Trimmer (Weight on Wheels)

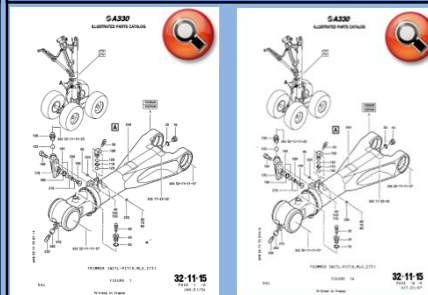
2. Job Set-up Information  
B. Referenced Information

### PROCEDURE

| REFERENCE        | DESIGNATION                                                                                    |
|------------------|------------------------------------------------------------------------------------------------|
| 29-00-00-864-804 | Put the Related Hydraulic System in the Depressureized Configuration before Maintenance Action |
| 32-00-00-860-804 | Flight Configuration Precautions                                                               |
| 32-11-15-991-001 | Fig. 401                                                                                       |

### VIDEO VIEW

### IPC VIEW



### MOCK-UP VIEW

# A330 Landing Gear Maintenance Training System

## VIEW



## VIDEO VIEW



## SPANNER – TR LINK NUT



**A340 / A330**  
ILLUSTRATED TOOL AND EQUIPMENT MANUAL

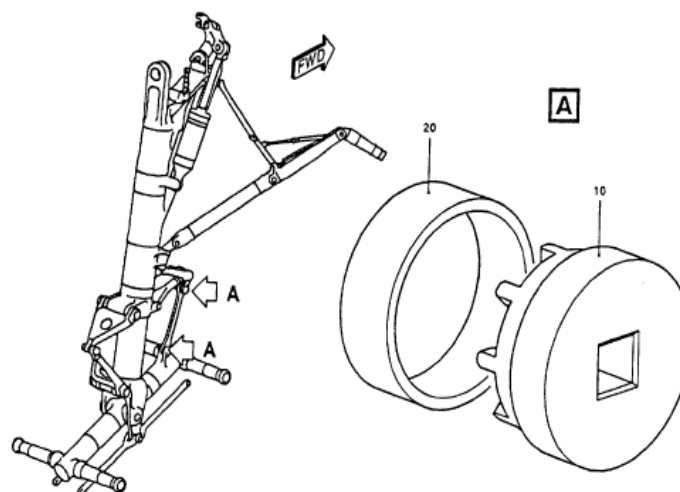
SPANNER – TR LINK NUT

PART NUMBER: 460007036

Description..... Used for the removal and installation of the nuts on the upper and lower pitch trimmer pins.

Weight ..... 1.0 kg (2.2 lb)

Dimensions..... Dia 79.4 x 44.5 mm (Dia 3.1 x 1.8 in.)



A3305394-1

| FIGURE<br>ITEM NO.     | PART NUMBER | NOMENCLATURE          | EFF. | UNITS<br>PER ASSY |
|------------------------|-------------|-----------------------|------|-------------------|
| R 2 - 1                | 460007036   | SPANNER – TR LINK NUT |      | RF                |
| 10                     | 460007036-1 | . SPANNER             |      | 1                 |
| 20                     | 460007036-2 | . COLLAR              |      | 1                 |
| - ITEM NOT ILLUSTRATED |             |                       |      |                   |

Figure 2

**32-11-15** Page 2  
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## TASK INFORMATION

TASK 32-11-15-000-801  
Removal of the MLG Bogie-Alignment  
Pitch Trimmer (Weight on Wheels)

Procedure  
(f. Fig. 401/TASK 32-11-15-991-001)  
Task 32-11-15-020-050  
Removal of the Bogie-Alignment  
Pitch-Trimmer

## PROCEDURE

Use the SPANNER - TR LINK NUT to remove the nut (9).  
Use the [SPANNER - A/LINK](#) to remove the nut (11).  
Hold the pitch trimmer (26) and remove the pin (21).  
Hold the articulating links (7), (12) and (17) and remove the pin (16).  
Remove and discard the cotter pins (27).  
Remove the nuts (3) and the washers (28).  
Move the pitch trimmer (26) downwards until you have sufficient room to remove the bolts (1). Do not put the hydraulic hoses or the 2M harness in tension. If necessary, compress the pitch trimmer (26).

**TE :** If a piston-head seal has failed, hydraulic fluid can come out of the bleeder (4).

Remove the bolts (1).

# Context Management

## ■ From the macro view

Distinguishing the landing gear on the left-hand side from that on right-hand side is not possible if only vision technologies are used. The ontological context is introduced for specifying contextual information.

The screenshot displays a software interface for aircraft maintenance, likely for a Boeing 737. It features three main panels:

- Left Panel (Component Tree):** A hierarchical tree structure under the 'Component' tab. The tree is expanded to show the 'MainLandingGear' sub-component, which includes:
  - ExtensionAndRetraction
  - GearsAndDoors
    - MainGearDoor
      - MainLandingGear
        - ArticulatingLink
        - BogieAlignmentPitch Trimmer
        - BogieBeamAssembly
        - ElectricalHydraulicDressing
        - MLGLeg
        - Pitch Trimmer Control Manifold Ass
        - Shortening Mechanism
        - Side Stay Assembly
        - Torque Link
      - NoseGearDoor
      - NoseLandingGear
    - Steering
    - WheelsAndBraking

- Center Panel:** A photograph of a landing gear assembly. A yellow circle highlights the 'Main Gear' area. Labels with red text are overlaid on the image:
- Gear and Door
- Main Gear
- Main Gear Door
- MLG Leg
- Shortening Mechanism
- Torque Link
- Bogie Alignment Pitch Trimmer
- Articulating Link
- Pitch Trimmer Control Manifold Assembly
- Side Stay Assembly
- Electrical Hydraulic Dressing
- Right Panel (Task List):** A list of tasks under the 'Task' tab. The tasks include:
- Adjustment\_Test
- ApprovedRepairs
- Cleaning\_Painting
- Deactivation\_Reactivation-Removal\_Installation
  - TASK 32-11-15-000-801
  - TASK 32-11-15-400-801
- DescriptionandOperation
- Inspection\_Check
- MaintenancePractice
- Servicing



# Context Management

## ■ From the micro view

Once a technician chooses a task, the IAR system narrows the scope of object recognition within the given context

| Component                | Task | Job | Instruction |
|--------------------------|------|-----|-------------|
| Job Set-up               |      |     |             |
| Subtask 32-11-15-941-050 |      |     |             |
| Subtask 32-11-15-860-050 |      |     |             |
| Subtask 32-11-15-865-050 |      |     |             |
| Procedure                |      |     |             |
| Subtask 32-11-15-020-051 |      |     |             |
| Subtask 32-11-15-020-050 |      |     |             |
| Close-up                 |      |     |             |

**CURRENT VIEW PREVIEW**



| Component                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Task | Job | Instruction |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----|-------------|
| (1) Remove the bleeder (4) together with the seal (5). Discard<br>(2) Put the container below the union nut of the hose (24).<br>(3) Disconnect the union nut of the hose (24) and let the hyc<br>(4) Put blanking plugs on the disconnected line ends.<br>(5) Move the hydraulic hose (24) away from the pitch trimmer<br>(6) Remove and discard the cotter pins (14) and (18).<br><b>(7) Remove the nuts (13) and (19), the washers (15) and (20)</b><br>(8) Use the SPANNER - TR LINK NUT to remove the nut (9)<br>(9) Use the SPANNER - A/LINK to remove the nut (11).<br>(10) Hold the pitch trimmer (26) and remove the pin (21).<br>(11) Hold the articulating links (7), (12) and (17) and remove<br>(12) Remove and discard the cotter pins (27).<br>(13) Remove the nuts (3) and the washers (28).<br>(14) Move the pitch trimmer (26) downwards until you have s<br>(15) Remove the bolts (1).<br>(16) Hold the pitch trimmer (26) and remove the pin (6) and tl<br>(17) Remove the pitch trimmer (26).<br>(18) Remove and keep the spacer bush (22).<br>(19) Install the bleeder (4). |      |     |             |

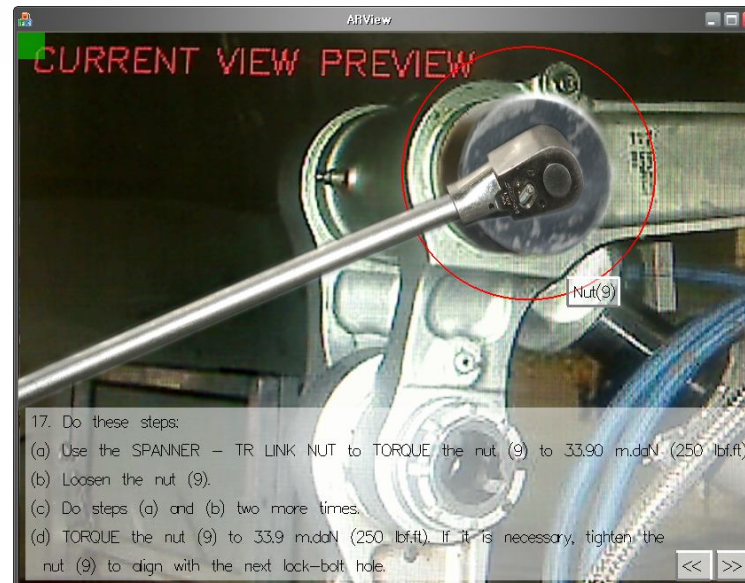
# Integration



1. The camera receives a real image from the aircraft, and then the AR module recognize the object.
2. After the recognition, the user triggers an event by clicking the mouse or giving a voice command with the display of an augmented object.
3. The Knowledge module finds related information send back to UI/UX from ontology-based repository
4. The AR module receives the current information and displays the output of related data and menus to the corresponding location in AR view.

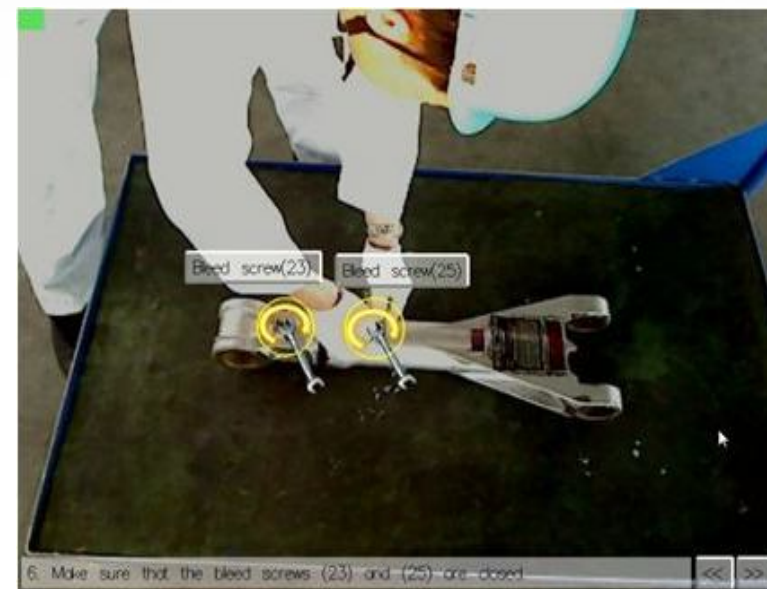
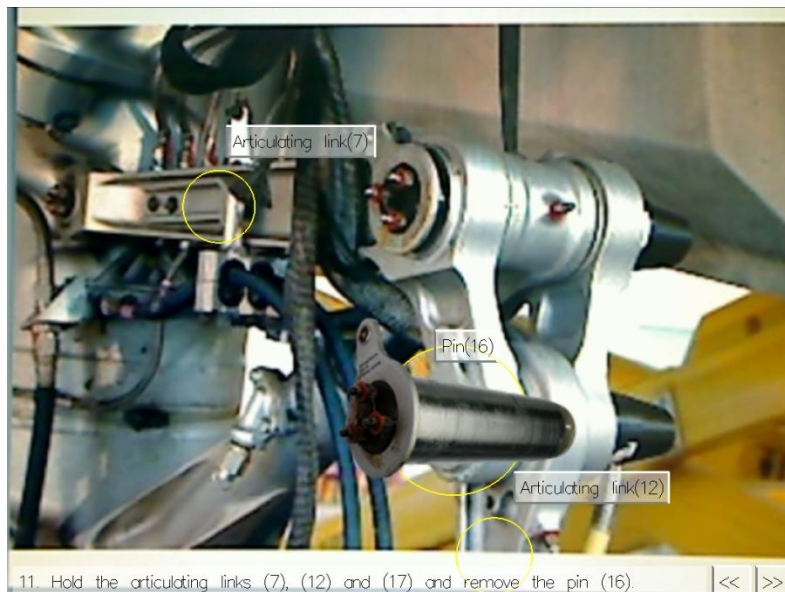
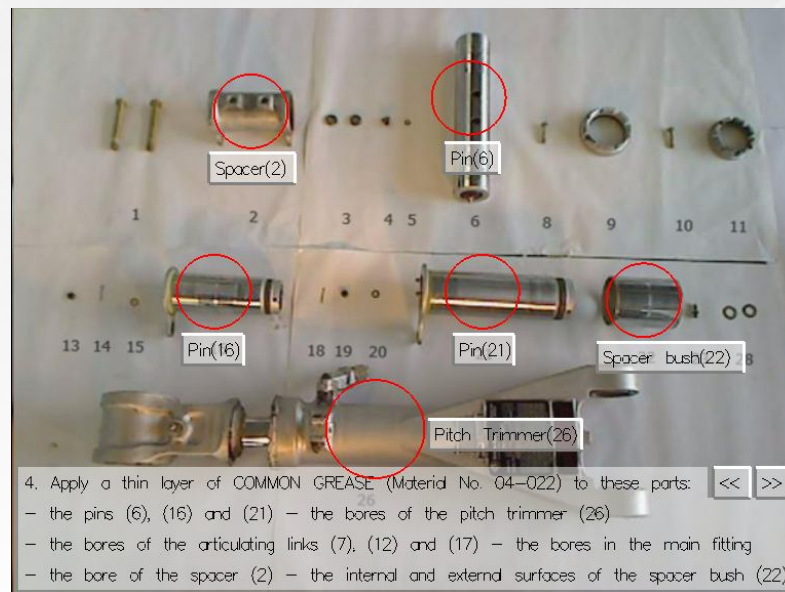


# Case Study – Removal

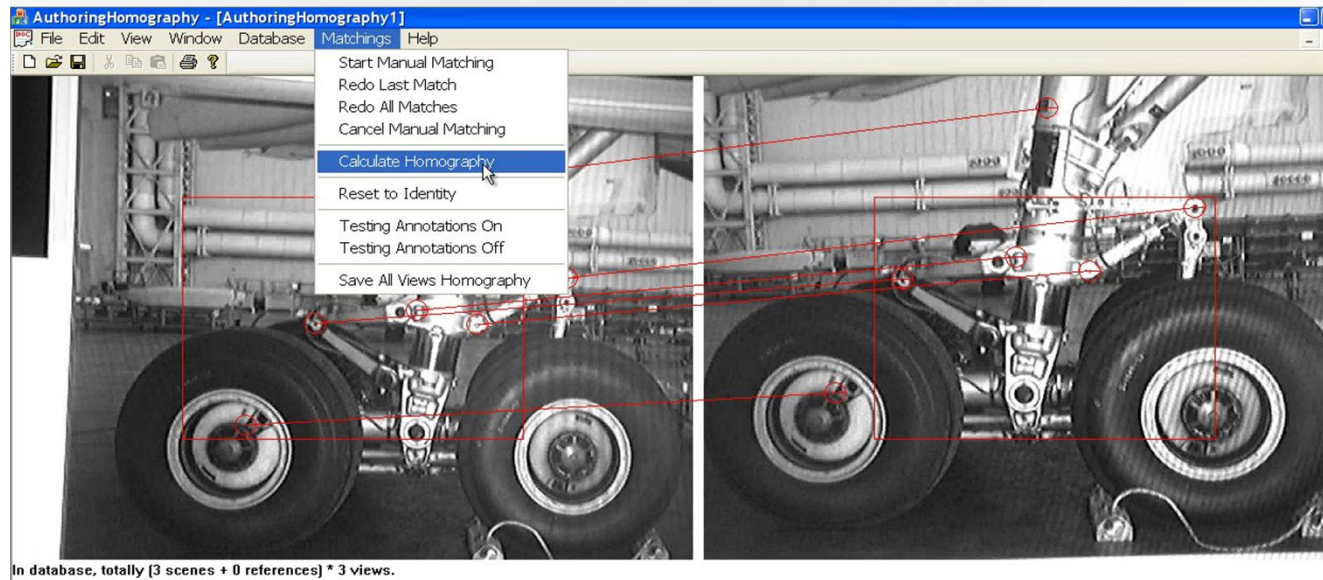




# Case Study – Installation

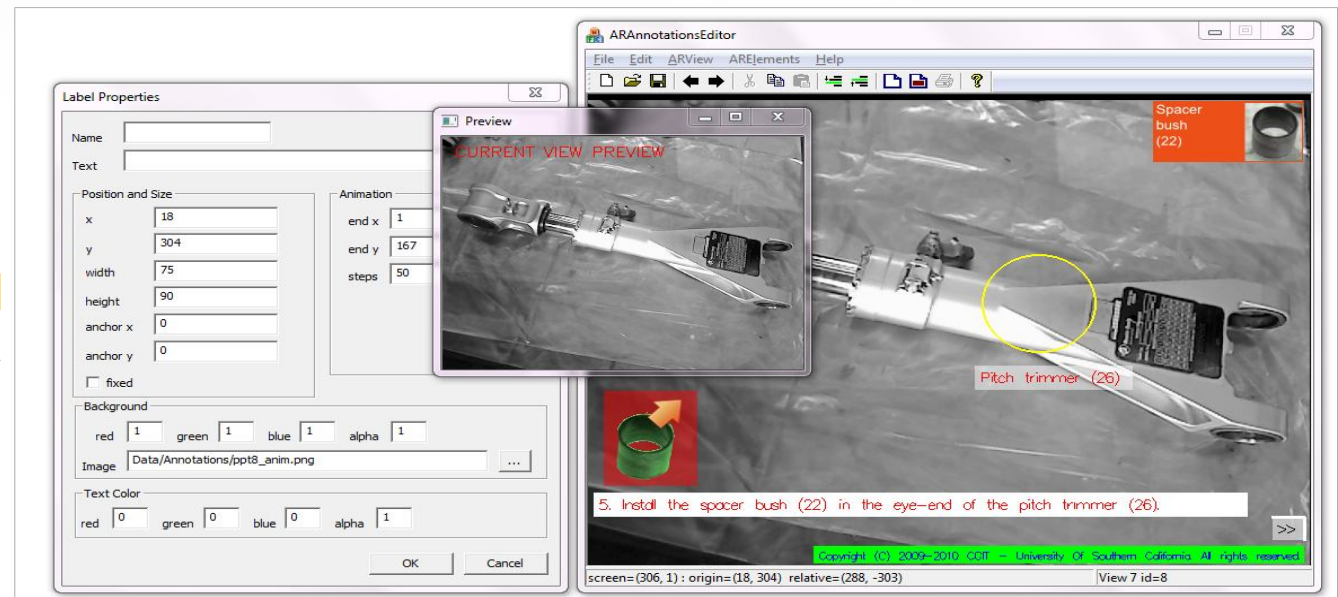


# Authoring Tool for AR



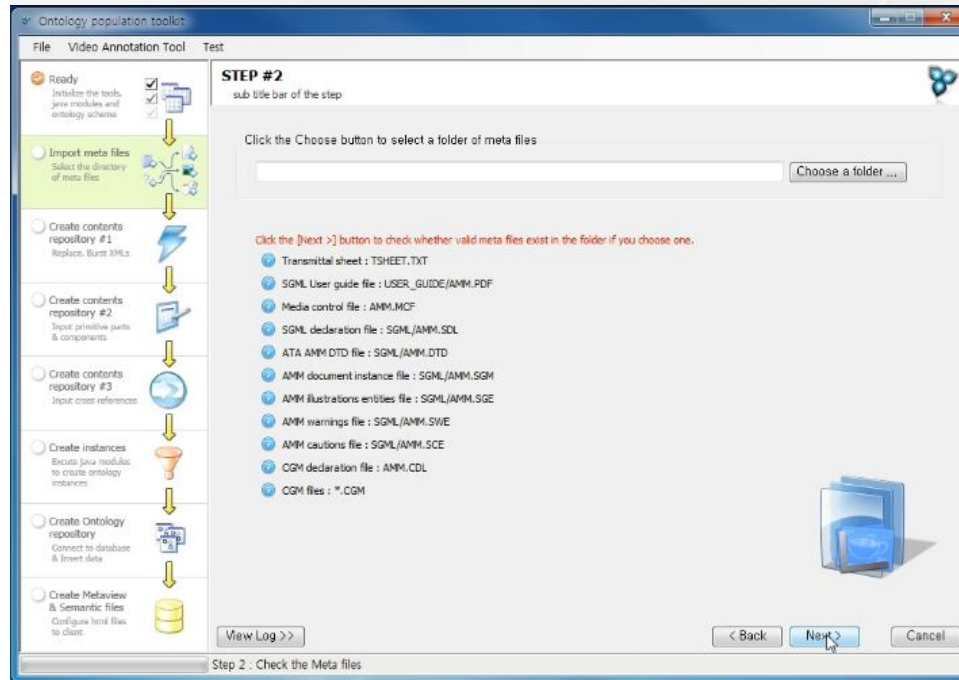
← **Authoring Tool**

**Animation Creation Tool  
for AR authoring** →



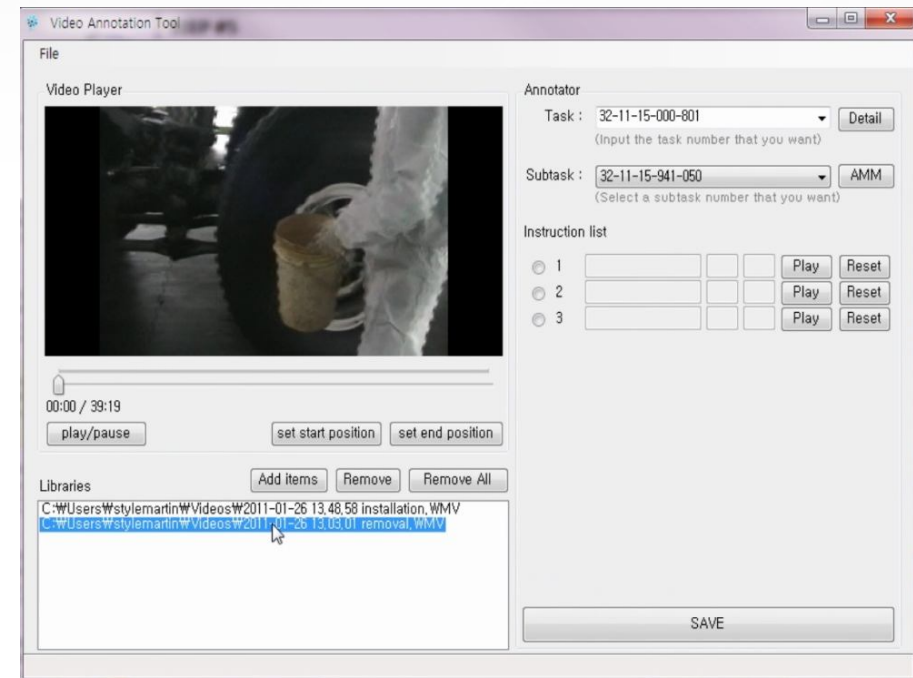


# Authoring Tool for Knowledge



← **Ontology Population Tool**

**Semantic Video Annotation Tool** →





# Demonstration Video

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# Benefits

- First, the amount of preparatory work for the technician decreased by about **40 minutes**.
  - This reduction came from the following areas: printing the AMM, checking the availability of necessary equipment, referring to instructions and related information.
- Second, there was a decrease in the actual repair time.
  - The technician finished a given task about **30 minutes** faster by using the IAR system than by taking the manual approach.
- Accordingly, about 30% of the total working time was reduced (From 240 minutes to 170 minutes).
- Finally, the IAR system was useful for the engineer as **a simulator for aircraft maintenance work at the task level** after the engineer completed basic training.

# Conclusion and Future Work

- A unified framework for AR and Knowledge to provide the specific context-based information to maintenance engineers
  - Context-aware camera views to execute specific technical instructions on real-time basis
  - Unified and summarized views for the integration of maintenance resources such as videos, photos, links, and figures, and other resources with manuals according to the current AR context
- AR and Knowledge Graph are complementary each other.
  - Natural UI/UX for KBS
  - Context-aware for AR
- Deep Learning for Image Recognition and Tracking for AR



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  - Context-aware camera views to execute specific technical instructions on real-time basis
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  - Context-aware for AR
- Deep Learning for Image Recognition and Tracking for AR

# References

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2. Geun-Sik Jo, et al., RANSAC vs CS-RANSAC, AAAI, 2015
3. Crescenzo, F.D., Fantini, M., Persiani, F., Stefano, L.D., Azzari, P., and Salti. S. Augmented reality for aircraft maintenance training and operations support. IEEE Computer Graphics and Applications, 2011
4. Fox, S. The Importance of Information and Communication Design for Manual Skills Instruction with Augmented Reality. Journal of Manufacturing Technology Management, 2010
5. Ha, I., Oh, K.J., Hong, M.D., Lee, Y.H., Rosli, A.N., and Jo, G.S. Ontology-driven visualization system for semantic searching. Multimedia Tools and Applications, 2014
6. Henderson, S., and Feiner, S. Exploring the Benefits of Augmented Reality Documentation for Maintenance and Repair. Journal IEEE Transactions on Visualization and Computer Graphics, 2011
7. Zhu, H., Gao, J., Li, D., and Tang, D. An Authorable Context-aware Augmented Reality System to Assist the Maintenance Technicians. The International Journal of Advanced Manufacturing Technology, 2012

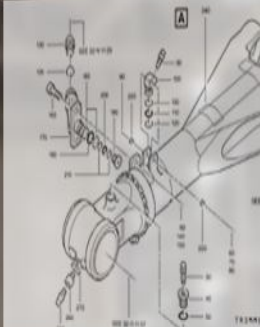
# References

## [Patents]

- Geun-Sik Jo and Kee Sung Lee, SERVER AND METHOD FOR TRANSMITTING AUGMENTED REALITY OBJECT. 2014 (US, Patent Filed)
- Geun-Sik Jo, UNIFYING AUGMENTED REALITY AND BIG DATA. 2014 (US, Patent Filed)
- Geun-Sik Jo, INTERACTION METHOD AND SYSTEM FOR UNIFYING AUGMENTED REALITY TECHNOLOGY AND BIG DATA, 2015 (EU, Patent Filed)
- And more than 10 patents issued and filed related to this topics in Korea and USA



The background image shows a person from the side, wearing white AR glasses. They are in an airport hangar with a large aircraft and yellow overhead cranes visible in the background. A digital overlay is projected onto the person's field of vision, displaying maintenance information for an A330 aircraft. The overlay consists of several panels: a small image of engine parts, text for 'A330 ILLUSTRATED PARTS Chapter 11 [IPC]', a photo of landing gear, text for 'A330 Chapter 32 Landing gear [IPC]', a photo of a pitch trimmer, text for '32-11-15 Pitch trimmer Part # : 26 [IPC] [AMM]', and a technical diagram of the trimmer assembly.

|                                                                                   |                                                         |                                                                                     |                                                    |                                                                                     |                                                                |                                                                                     |
|-----------------------------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------|
|  | <b>A330</b><br>ILLUSTRATED PARTS<br>Chapter 11<br>[IPC] |  | <b>A330</b><br>Chapter 32<br>Landing gear<br>[IPC] |  | <b>32-11-15</b><br>Pitch trimmer<br>Part # : 26<br>[IPC] [AMM] |  |
|-----------------------------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------|

Thank you

