ConstAR

(Constraint Optimisation Problems + AR)

Abstract

Given the 3D spatial nature of real-world constraint optimisation problems, we investigated the effectiveness of visualising solutions to an aircraft cargo 3D bin-packing constraint problem in Augmented Reality to facilitate analysis and user interaction with optimisation systems.

Our contributions include the results of a 5-participant preliminary usability study capturing initial evidence on the viability, workload dimensions, and limitations of AR for improving solutions to constraint optimisation problems.

Background

Modelling real-world constraint problems is difficult when a constraint programmer is unfamiliar with the problem domain. Collaborating with domain experts helps define requirements but commmunicating those requirements and candidate solutions found creates its own challenges.

Given the 3D spatial nature of real-world problems, and the analysis tasks required when evaluating the quality of solutions, greater complexity is required to evaluate and capture the real-world requirements.

Usability Study

To gather initial evidence on the viability of the ConstAR system and elicit feedback on its limitations we captured qualitative and quantitive data through a remotely conducted usability study with 5 participants.

Participants completed:

- A pre-study questionnaire on their AR and domain experience

Four tasks were assigned:

- A 'repetitive with changed conditions' task where the participant repeats an interaction 7 times
- Explore all the systems capabilities
- Free exploration, no goal *(5 minute limit)*
- Free exploration, goal is to maximise profit *(10 minute limit)*

Post study:

- Semi-structured interviews were conducted
- A questionnaire measuring workload for 9 separate dimensions was completed

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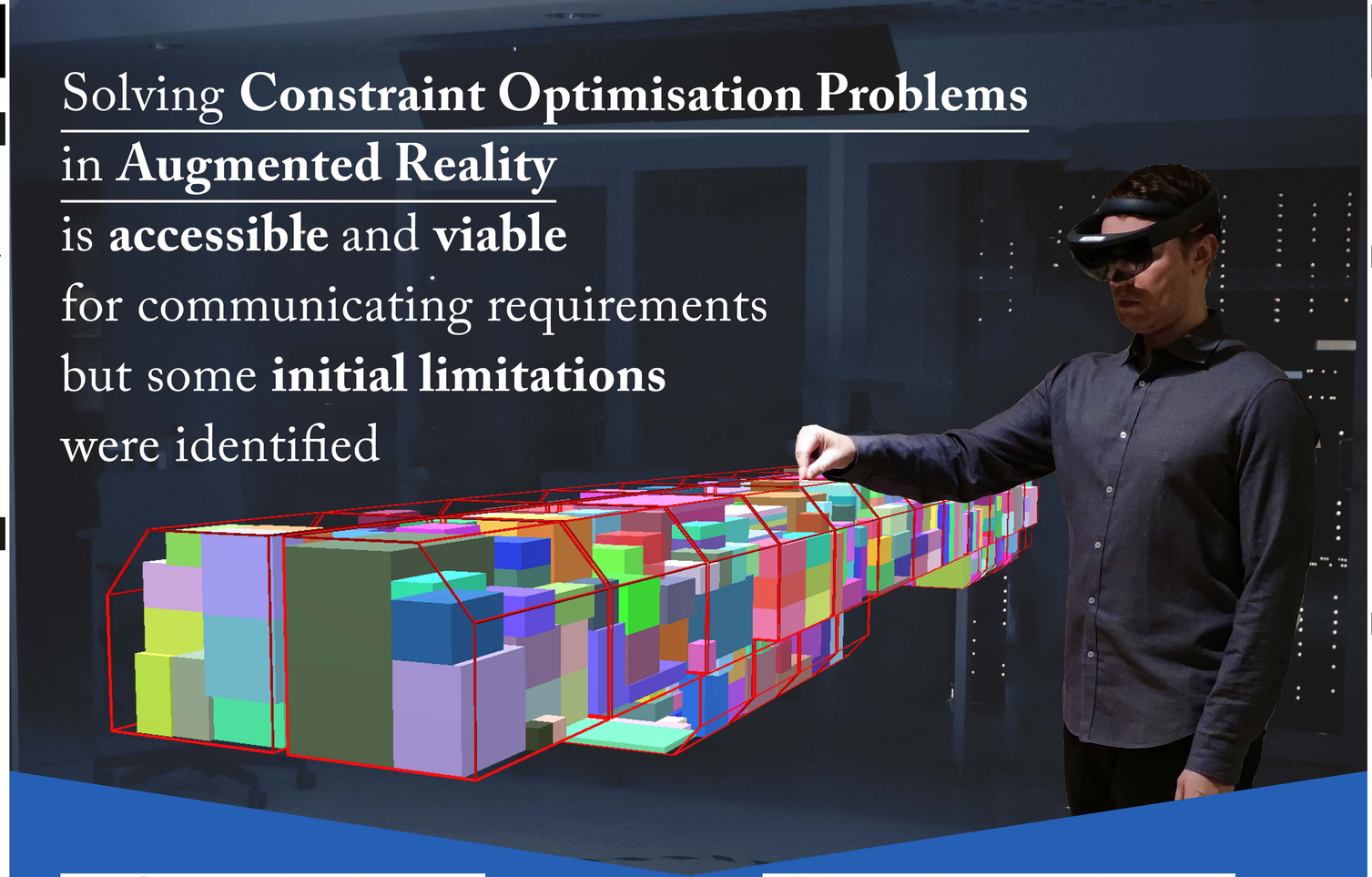
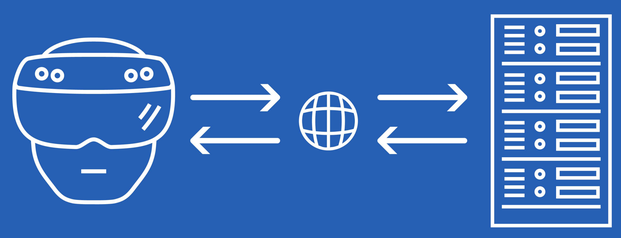


The Optimisation Problem

- 3D bin-packing
- Domain: Airplane Cargo
- 42 Containers, 300+ items
- Items have weight
- Items have profit
- ▼ Minimise Weight ▲ Maximise Profit

System Design

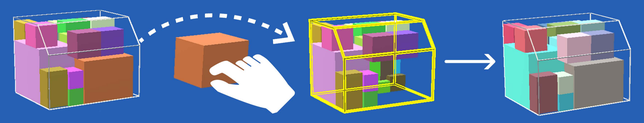
Client-server architecture:



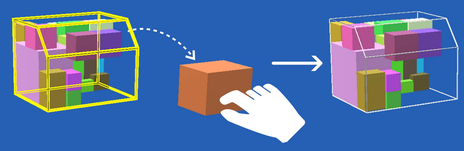
The ***HoloLens*** facilitates interactive visualisation and querying while the ***server*** solves constraint problem instances.

AR Interactions Implemented

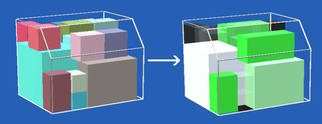
MOVE ITEM



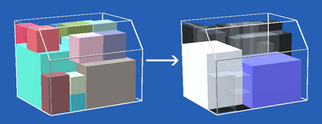
REMOVE ITEM



FILTER BY PROFIT



FILTER BY WEIGHT



Filter renders only the items above a selected ***weight*** or ***profit*** threshold. The filtered items are then coloured according to their ***weight*** or ***profit***.

Results

The ConstAR system is viable for analysing constraint problem solutions, improving them, and communicating requirements. Initial limitations with interactions for analysis, spatial reasonsing and efficiency were identified.

#1 SIM-TLX

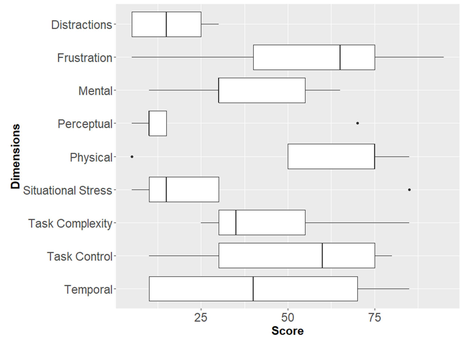


Fig 1: Boxplot of the SIM-TLX questionnaire results with 9 dimensions.

#2 Task 1 - Total time taken per part

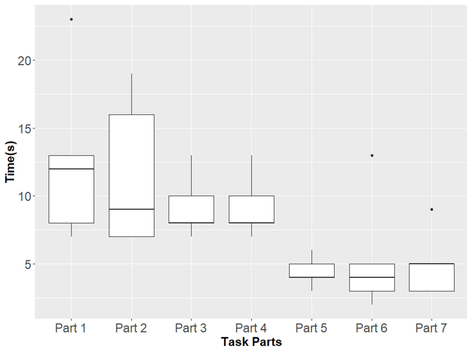
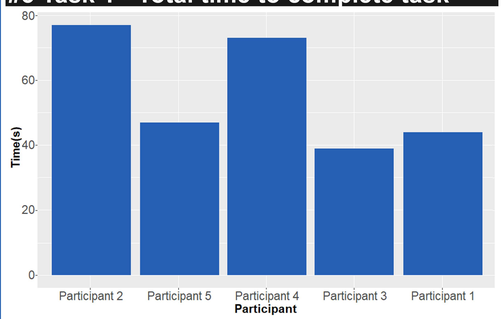


Fig 2: Boxplot of timing distributions for all seven parts of Task1.

#3 Task 1 - Total time to complete task



#4 Task 1 - Total Attempts

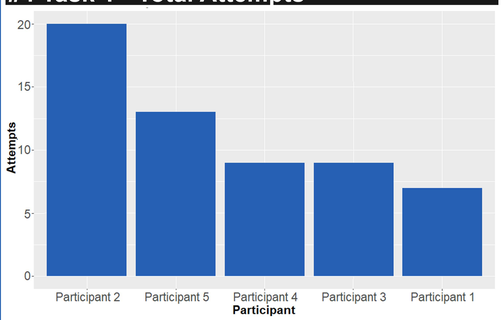


Fig 3 & 4: The sum of all interaction timings and attempts *(failed and successful)* for each participant to complete Task 1. Ordered by their experience with AR from 1-Lowest *(left)* to 5-Highest *(right)*.