

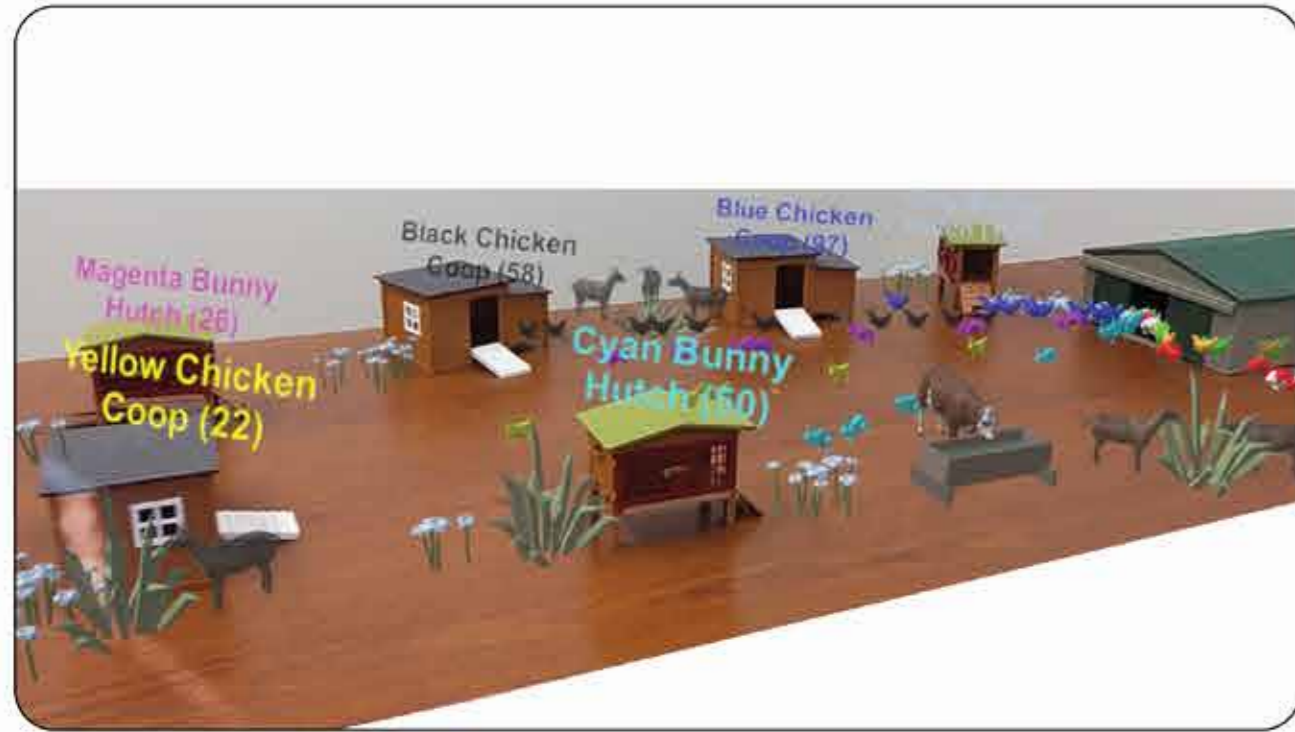
Enriching Physical-Virtual Interaction in AR Gaming by Tracking Identical Real Objects

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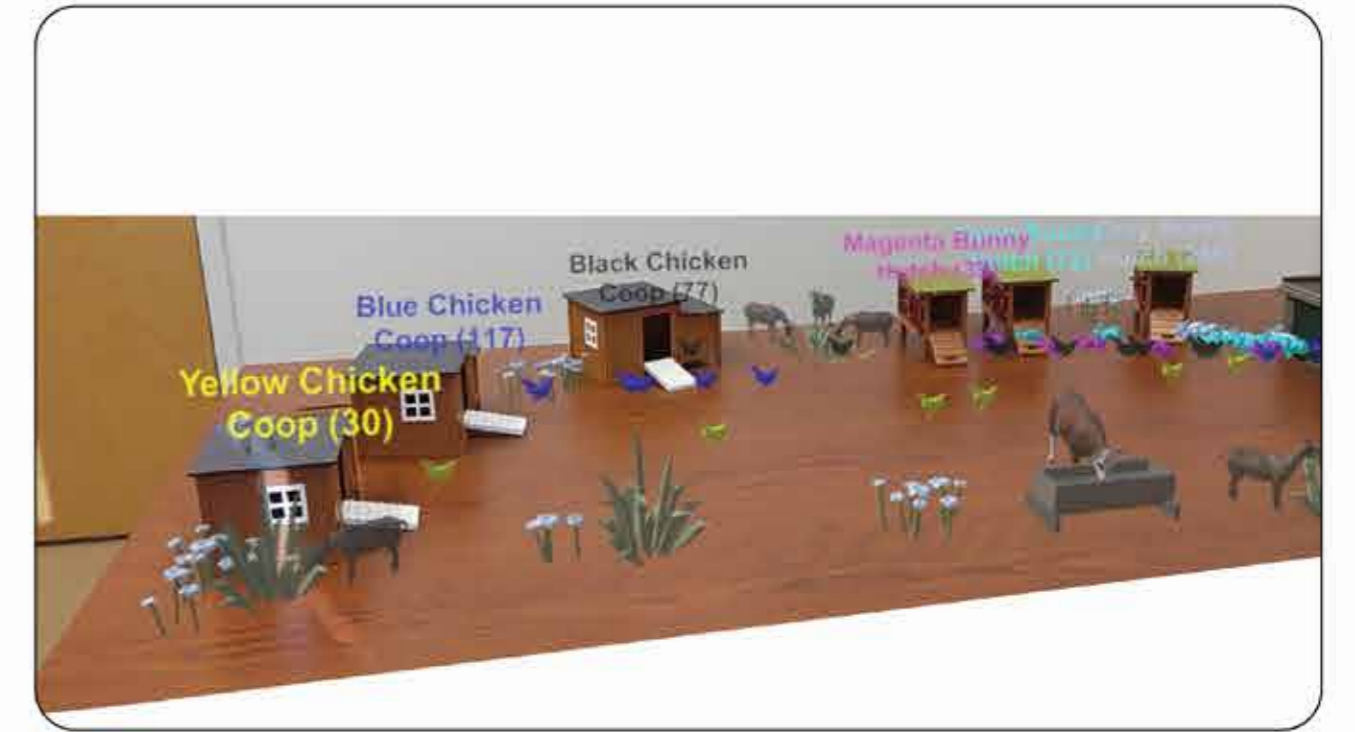
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(a) Initial Game Scene



(b) Layout Being Changed

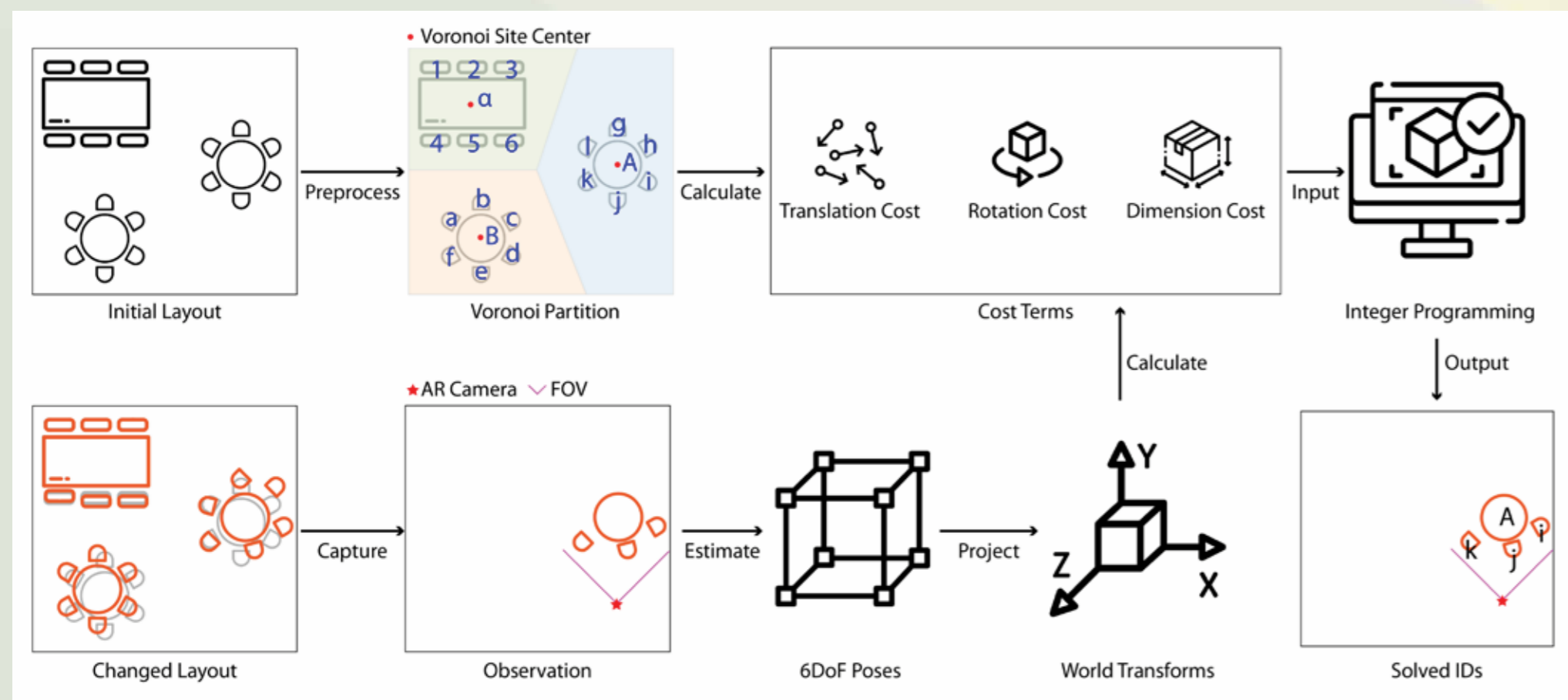


(c) Updated Game Scene

1 Abstract

We present a novel approach to address the tracking of identical objects in an AR scene to enrich physical-virtual interaction. Our method leverages partial scene observations captured by an AR headset, utilizing the perspective and spatial data provided by this technology. Object identities within the scene are determined through the solution of a label assignment problem using integer programming. To enhance computational efficiency, we incorporate a Voronoi diagram-based pruning method into our approach. Our implementation of this approach in a farm-to-table AR game demonstrates its satisfactory performance and robustness. Furthermore, we showcase the versatility and practicality of our method through applications in AR storytelling and a simulated gaming robot.

2 Approach



The above figure shows an overview of our technical approach. At the beginning, we partition the scene via a Voronoi diagram, which is regarded as the search space for possible labels of detected objects in the changed layout. As objects are moved in the scene, an AR camera captures images of the scene based on which objects are detected. The pose estimation algorithm computes objects' 6DoF poses. Since the pose of the AR camera is known, we can project the detected objects back into the real world. After that, we can calculate the costs: translation cost, rotation cost, and dimension cost between possible objects in the initial layout and detected objects in the changed layout. These costs will be input into our integer programming approach, which determines the identities of the detected objects.

3 Results

3.1 Farm-to-Table AR Game



(a) Initial Game Scene

(b) Updated Game Scene

A demonstration of our AR headset Farm-to-Table game. (a) illustrates the initial game scene before any layout change, while (b) portrays the updated game scene after executing the layout changes and running our object label assignment algorithm. We can deduce the following layout adjustments from (b): (1) swapping Blue Chicken Coop and Cyan Bunny Hutch positions; (2) moving Magenta Bunny Hutch left of Cyan Bunny Hutch; (3) slightly shifting Yellow Chicken Coop away from the headset.

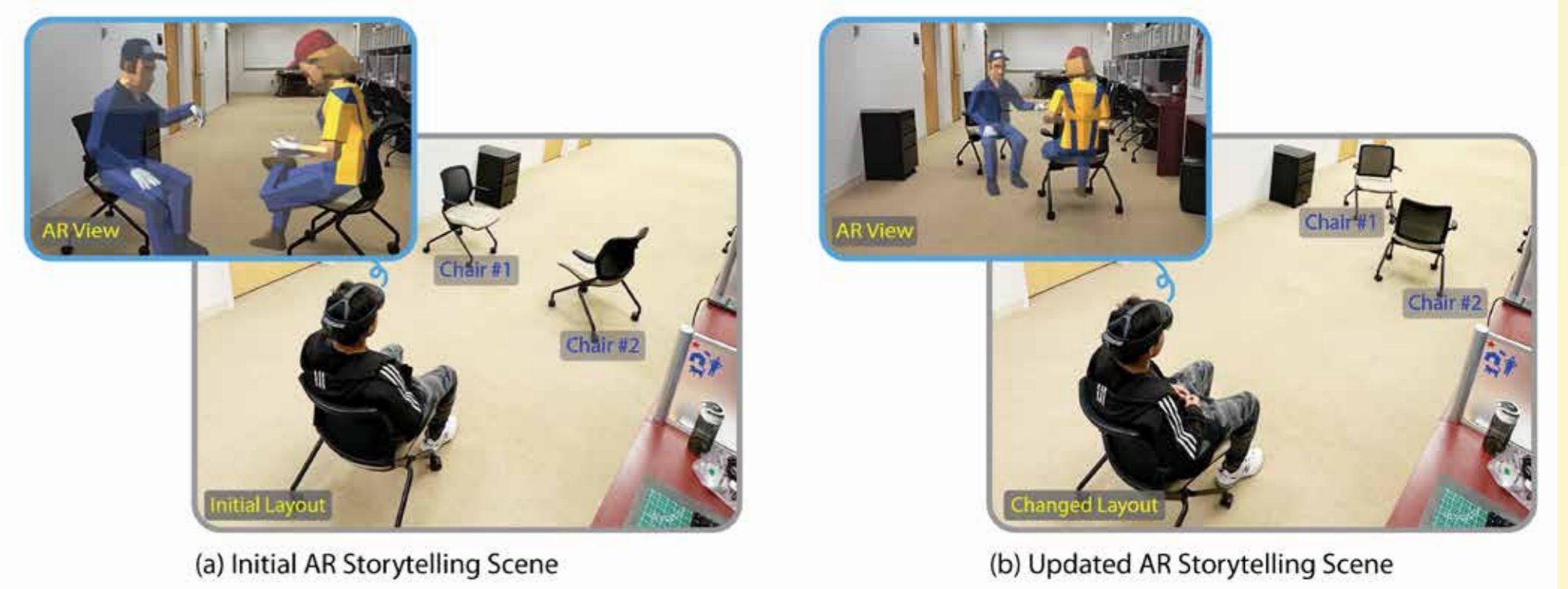


(a) Initial Game Scene

(b) Updated Game Scene

Another demonstration of our AR headset Farm-to-Table game. (a) illustrates the initial game scene before any layout change, while (b) portrays the updated game scene after executing the layout changes and running our object label assignment algorithm. From the label assignment result, we can infer two layout changes: (1) swapping Orange Chicken Coop and White Bunny Hutch positions, and (2) rotating these objects.

3.2 AR Storytelling Showcase

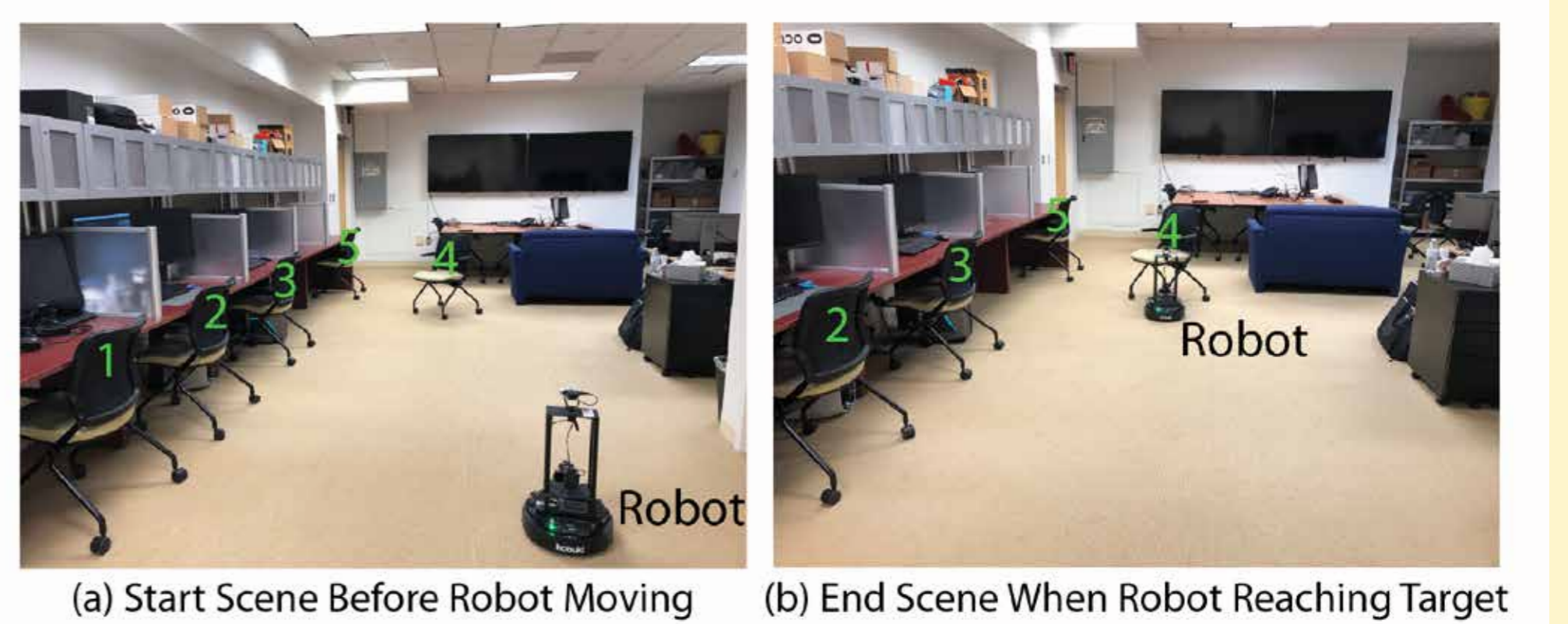


(a) Initial AR Storytelling Scene

(b) Updated AR Storytelling Scene

An AR storytelling example. (a) The initial view of an AR story where two virtual characters sit on real chairs. (b) An updated AR view showing that the two virtual characters still sat on the same chairs as before in the changed layout.

3.3 Gaming Robot Showcase



(a) Start Scene Before Robot Moving

(b) End Scene When Robot Reaching Target

The gaming robot simulation. (a) The changed layout in the real world in the beginning; (b) the scene when the robot reaches the target in the end.

4 Conclusion

We presented a novel approach to enrich physical-virtual interaction in AR gaming by tracking identical real objects. Our method leverages partial scene observations captured by an AR headset and solves object identities by integer programming. First, we explored its effectiveness through comprehensive quantitative experiments. Second, we implemented a Farm-to-Table AR game to validate our approach. Moreover, we presented two potential applications, AR storytelling and gaming robot, that could benefit from our approach.