Informatics

Context-Responsive Labeling in Augmented Reality

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Problem Definition and Motivation

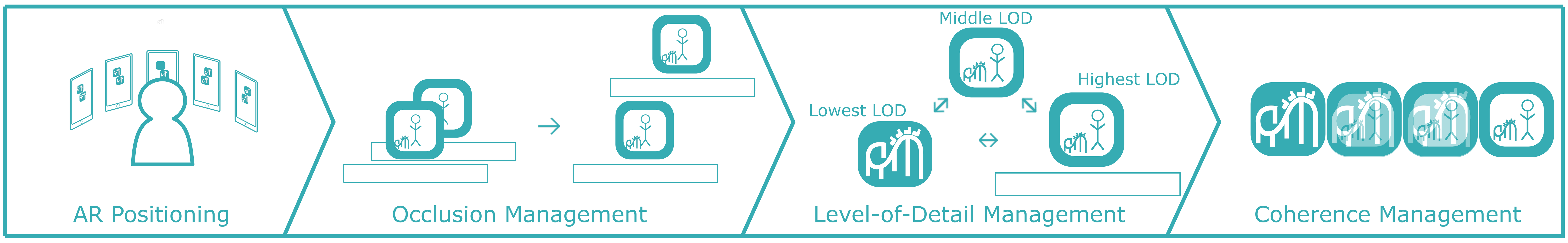
If a person needs to decide the next place to visit, he or she can extract knowledge about these Points-of-Interest (POIs) using 2D maps. However, while using a 2D map for navigation, users need to remap or translate the objects on the map to the real environment. Augmented Reality (AR) enables mobile users to explore the surrounding POIs in a real-world environment. Annotating POIs with labels in AR will lead to unwanted overlaps, and thus a context-responsive strategy to properly arrange labels is expected.

Contributions

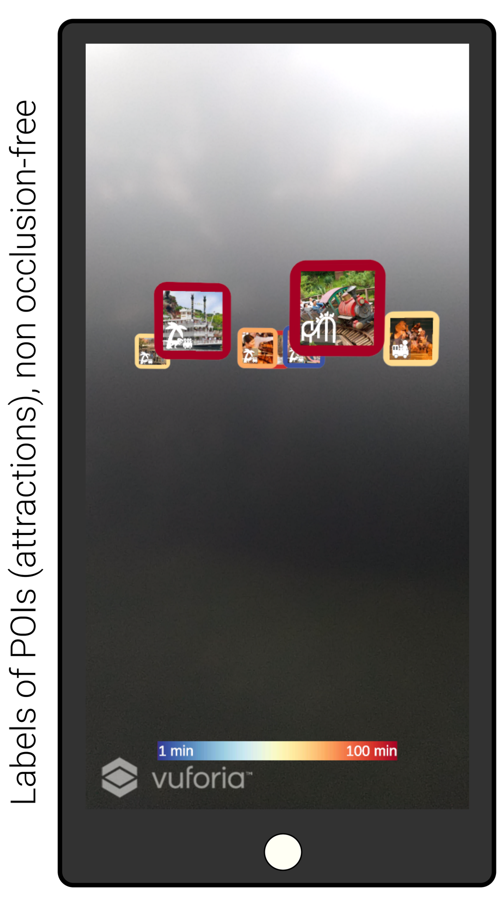
- A fast label occlusion removal technique for mobile devices.
- A clutter-aware Levels-of-Detail management.
- A 3D object arrangement that retains label coherence.
- An AR system on mobile devices to demonstrate the applicability of the label placement.

The Proposed Pipeline and Results

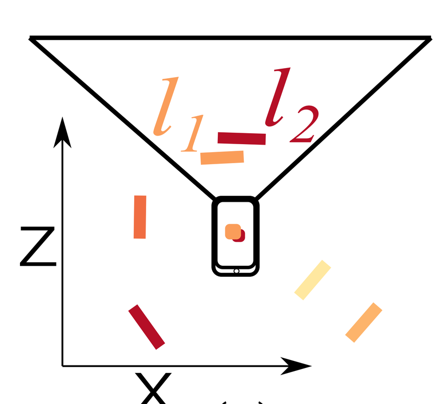
The pipeline beneath illustrates our steps to arrange labels in AR. The results show one of our datasets, a Tokyo Disneyland Dataset. Labels encode names, waiting times (color coding), attraction types, and locations of attractions.



Labels are initially positioned in AR in a 3D scene. Close labels occlude distant labels.

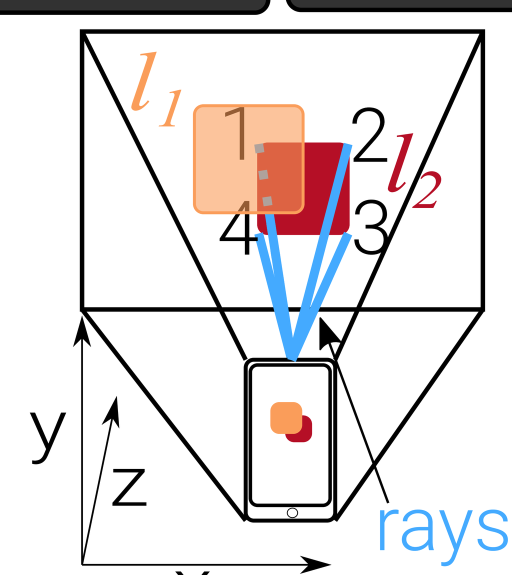


We use a Cartesian coordinate system where the xz-plane is parallel to the ground and the y-axis is the upward axis. Labels are arranged in 3D around the user (1). The labels are aligned towards the position of the user's device. Label l_1 occludes label l_2 on the mobile phone screen in the example below (1).



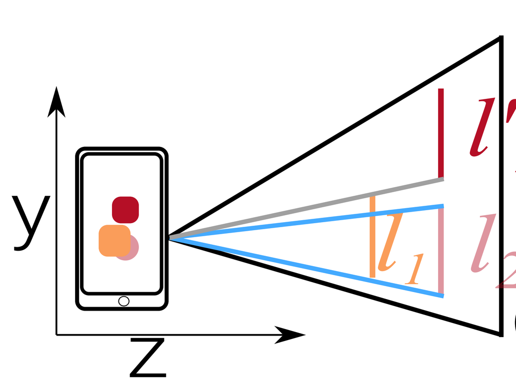
(1)

Label occlusions are resolved depending on the position of the user to support the exploration process. Distant labels are shifted upwards.



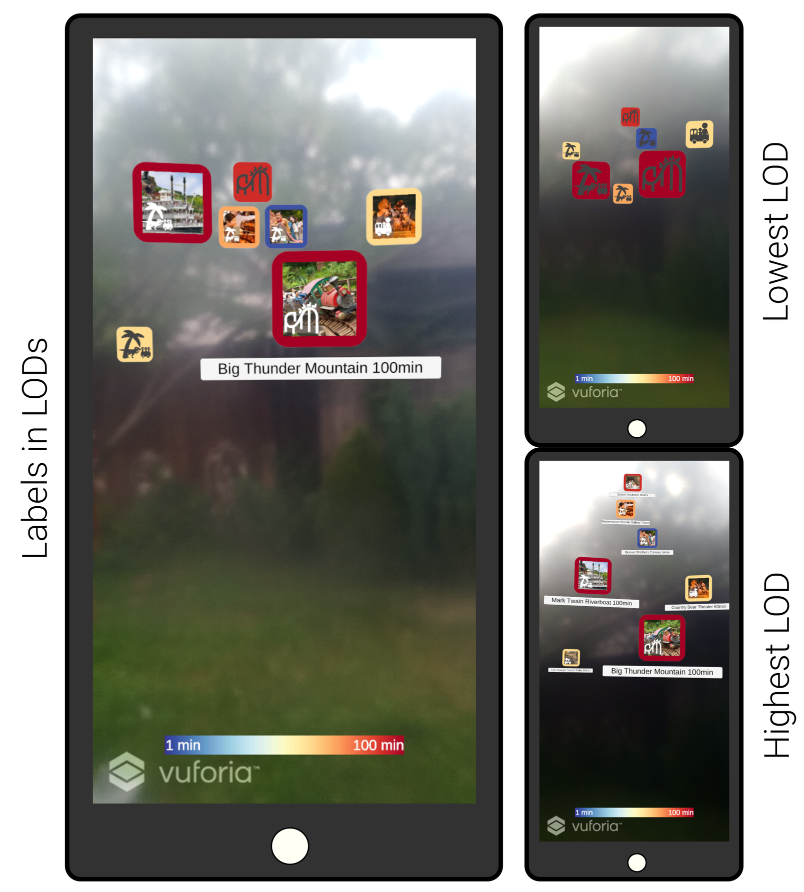
(2)

Occlusions are resolved iteratively by a greedy approach from close to far labels. Rays are traced to the corner points of each label to detect occlusions (2). In this example, the ray to corner 1 of l_2 collides with label l_1. Label l_2 is shifted upwards along the y-axis to be completely visible (3).

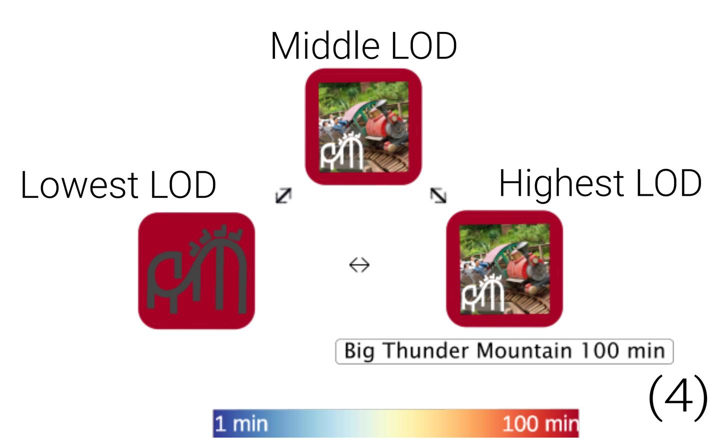


(3)

Labels are displayed in several LODs depending on the position of the user and the label density around the user.



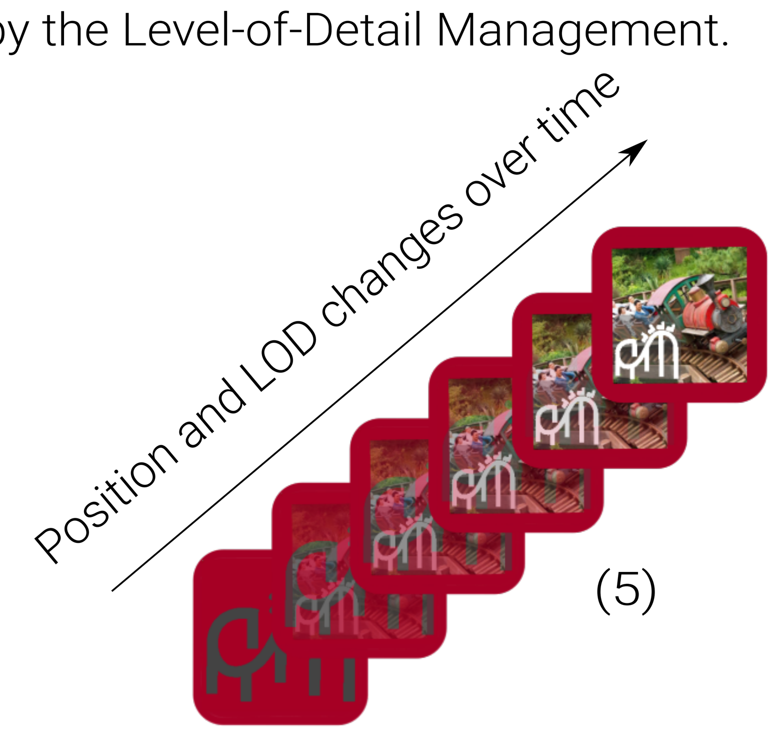
We include three LODs for individual labels (4). The Lowest LOD shows a color-coded scalar value and an icon of the POI. The Middle LOD adds a photo of the POI. The Highest LOD further presents a text tag. We measure the angle between the vector pointing towards a label and the ground plane. The larger this angle, the lower is the displayed LOD for a label. LODs are assigned from close to far labels. We use 0 - 20° for the Highest LOD, 21° - 30° for the Middle LOD, and more than 30° for the Lowest LOD. These values were found heuristically to reduce visual clutter and vertical stacking of labels.



(4)

Position or LOD changes of labels are smoothly resolved independent of the orientation of the user's device to avoid flickering and abrupt changes.

When the user interacts with the system and his or her location changes, label positions need to be updated to remain occlusion-free. To ensure coherent updates, we linearly implement changes. Label positions are adapted to be occlusion-free as computed by the Occlusion Management. The alpha channels of the icons, the photos, or the text tags are manipulated over time (5) if the LODs for labels change as calculated by the Level-of-Detail Management.



(5)

Evaluation and Conclusion

Our qualitative evaluation shows that participants can perform route planning tasks better and faster using our AR approach compared to 2D maps. The introduced label encoding supports the decision-making process of participants compared to plain text labels. Our greedy label positioning allows the execution on mobile devices. The LODs for labels reduce visual clutter on the mobile phone screen. Coherent updates enable smooth transitions of label positions and LODs.