

# An Intuitive Spatial AR System for Augmenting Planar Scenes in Industrial Settings

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## Abstract

Augmented reality (AR) promises to enable use cases in industrial settings that include the embedding of work steps directly into the scene, potentially reducing or altogether obviating the need for workers to refer to instructions in paper form or on a screen. In turn, spatial AR is a form of AR whereby the augmentation of the scene is carried out using a projector, with the advantage of rendering the augmentation visible to all onlookers simultaneously without calling for each to wear AR glasses. However, care must be taken to distort the images to be projected in a manner that they appear undistorted to the viewer, since the geometry of the scene as it relates to the geometry of the projector plays a role in how the pixels of the projector's image plane map to points in the scene. For planar scene geometry (such as a floor, wall, or table), this can be done in a cumbersome manual process called keystone correction, often using software bundled with the projector. We propose a system that produces the same effect by placing the desired augmentations intuitively in accordance with an image of the scene acquired by a camera. We achieve this by distorting the image to be projected using a plane-induced homography computed to produce the effect of projecting the image not from the actual projector pose, but in accordance with a *virtual* projector pose (i) facing directly downwards to the scene plane and (ii) rotated to place the image plane of the virtual projector in line with that of the camera.

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## 1. Introduction

A central challenge of spatial AR, however, the geometry of the scene as it relates to the geometry of the projector plays a role in how the pixels of the projector’s image plane map to points in the scene. This is why, unless special  
5 care is taken,

While pointing a projector at a scene and projecting an image is on its own not a challenge, doing so in a manner such that the projected content appear to be naturally part of the scene is more tricky. The intuition for the general problem we face can be drawn from using a projector to project an  
10 image to a flat wall: unless the projector faces the wall frontally, the bounds of a projected rectangular image will not appear rectangular, but more generally as a trapezoid (i.e., the image will appear distorted). The cause for this effect is that the geometry of the scene as it relates to the geometry of the projector plays a role in how the pixels of the projector’s image plane map to points in  
15 the scene.

The central objective we set for ourselves is to enable correcting for distortion caused by projecting to arbitrary scene geometry in an automatic fashion. This is to be done in a manner that lends itself to practical application in a real-world setting where the scene to be augmented—e.g., an object being gradually assem-  
20 bled and its placement relative to the projector—does not remain static. Finally, the solution is ideally to rely on the existing hardware setup—i.e., projector with steerable mirror system and stereo camera—mounted in the Pilotfabrik of TU Vienna.

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## References

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