Jigsaw - Multi-Modal Big Data Management in Digital Film Production

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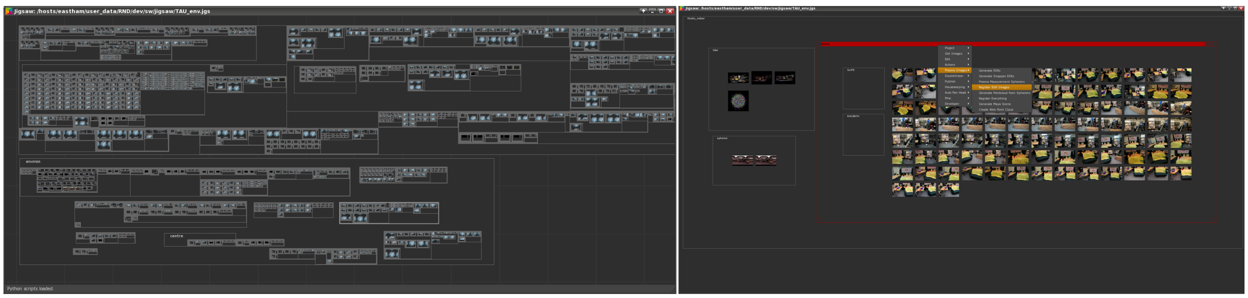

Figure 1: *Jigsaw is a big data management software developed by Double Negative. It allows artists to efficiently organize and process the vast amount of heterogeneous data captured on a movie set for digital post production.*

1 Introduction

Modern digital film production uses large quantities of data captured on-set, such as videos, digital photographs, LIDAR scans, spherical photography and many other sources to create the final film frames. The processing and management of this massive amount of heterogeneous data consumes enormous resources. We propose an integrated pipeline for $2D/3D$ data registration aimed at film production, based around the prototype application *Jigsaw*. It allows users to efficiently manage and process various data types from digital photographs to $3D$ point clouds. A key step in the use of multi-modal $2D/3D$ data for content production is the registration into a common coordinate frame (*match moving*). $3D$ geometric information is reconstructed from $2D$ data and registered to the reference $3D$ models using $3D$ feature matching [Kim and Hilton 2014]. We present several highly efficient and robust approaches to this problem. Additionally, we have developed and integrated a fast algorithm for incremental marginal covariance calculation [Ila et al. 2015]. This allows us to estimate and visualize the $3D$ reconstruction error directly on-set, where insufficient coverage or other problems can be addressed right away. We describe the fast hybrid multi-core and GPU accelerated techniques that let us run these algorithms on a laptop. *Jigsaw* has been used and evaluated in several major digital film productions and significantly reduced the time and work required to manage and process on-set data.

2 Our Approach

Fig. 2 shows the overall process for the integrated multi-modal data registration. We assume that the $3D$ point cloud obtained from LIDAR scans is the target reference to register other modalities.

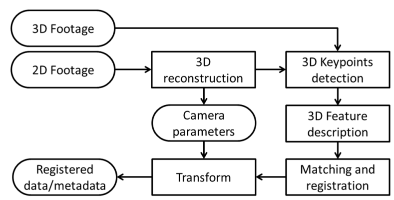

Figure 2: *$2D/3D$ workflow for registration*

$3D$ data from active range sensors is directly registered to LIDAR through $3D$ feature detection and matching. $2D$ footage is registered via $3D$ reconstruction such as stereo matching or Structure from Motion (SfM) techniques. For example, high dynamic range spherical imaging is often used to capture high resolution environment maps and lighting conditions on-set. Geometry from spherical images can be recovered by vertical stereo matching. The output is a $3D$ scene containing all reconstructed data in a common coordinate frame.

Contributions We present *Jigsaw* and its integrated pipeline for exploring, organizing and processing data captured on-set. We use highly efficient and robust algorithms exploiting multi-core CPUs and GPUs for the key steps of the workflow. Our optimized GPU solvers for sparse matrices with variable block sizes for example allow us to run a fast Bundle Adjustment on an on-set laptop to get a first look at the captured data. Previously many problems in captured data were only detected in post-production, often weeks after principal photography when it was too late to correct. The multi-modal $2D/3D$ film production dataset used in this work has been released publicly for research at: `http://cvssp.org/impart` [1]

References

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KIM, H., AND HILTON, A. 2014. Hybrid $3D$ Feature Description and Matching for Multi-modal Data Registration. In *Proc. ICIP 2014*.

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