Automatic Geometric Registration of Dense Range Scans for 3D Site Modeling

Ioannis Stamos and Peter K. Allen †
Computer Science Dept, Hunter College, City University of New York, NY, NY 10021
Computer Science Dept, Columbia University, New York, NY 10027 †

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We are building a system that can automatically acquire 3D range scans and 2D images to build geometrically and photometrically correct 3D models of urban environments [2]. A major bottleneck in the process is the automated registration of a large number of geometrically complex 3D range scans in a common frame of reference. In this paper we provide a novel method for the accurate and efficient registration of a large number of complex range scans [3]. The method utilizes 1) range segmentation, 2) linear feature extraction 3) global graph search algorithms and 4) simultaneous ICP. First, we automatically compute pairwise registrations between individual scans. This is done using stable linear features extracted from a planar segmentation step. From these registrations, we build a topological graph, with a metric between graph nodes that represents the degree of confidence in our pairwise registration transformation. We can then search this graph to find a set of transformations that will globally reduce the error in registration and produce a globally coherent registered model. Simultaneous ICP can then be applied to further improve the registration. The algorithms do not assume any a-priori knowledge regarding the position of the sensors except that some overlap is assumed. The views do not have to be spatially close with respect to each other.

We will present results for building large-scale 3D models of historic sites and urban structures [1] consisting of over one hundred large-scale range images. The methods are also being used to register 2-D imagery with the 3-D model to provide both photometric and geometric correct models. Our range to image registration algorithm can increase the flexibility of the system by decoupling the relatively slow geometric model recovery process from the image acquisition process; the camera does not have to be precalibrated and rigidly attached to the range sensor. Vanishing points in the 2-D images are used to find calibration and rotational transformation parameters, and linear features are used for finding the translational components. Our system is comprehensive in that it addresses all phases of the modeling problem with a particular emphasis on automating the entire process.

References

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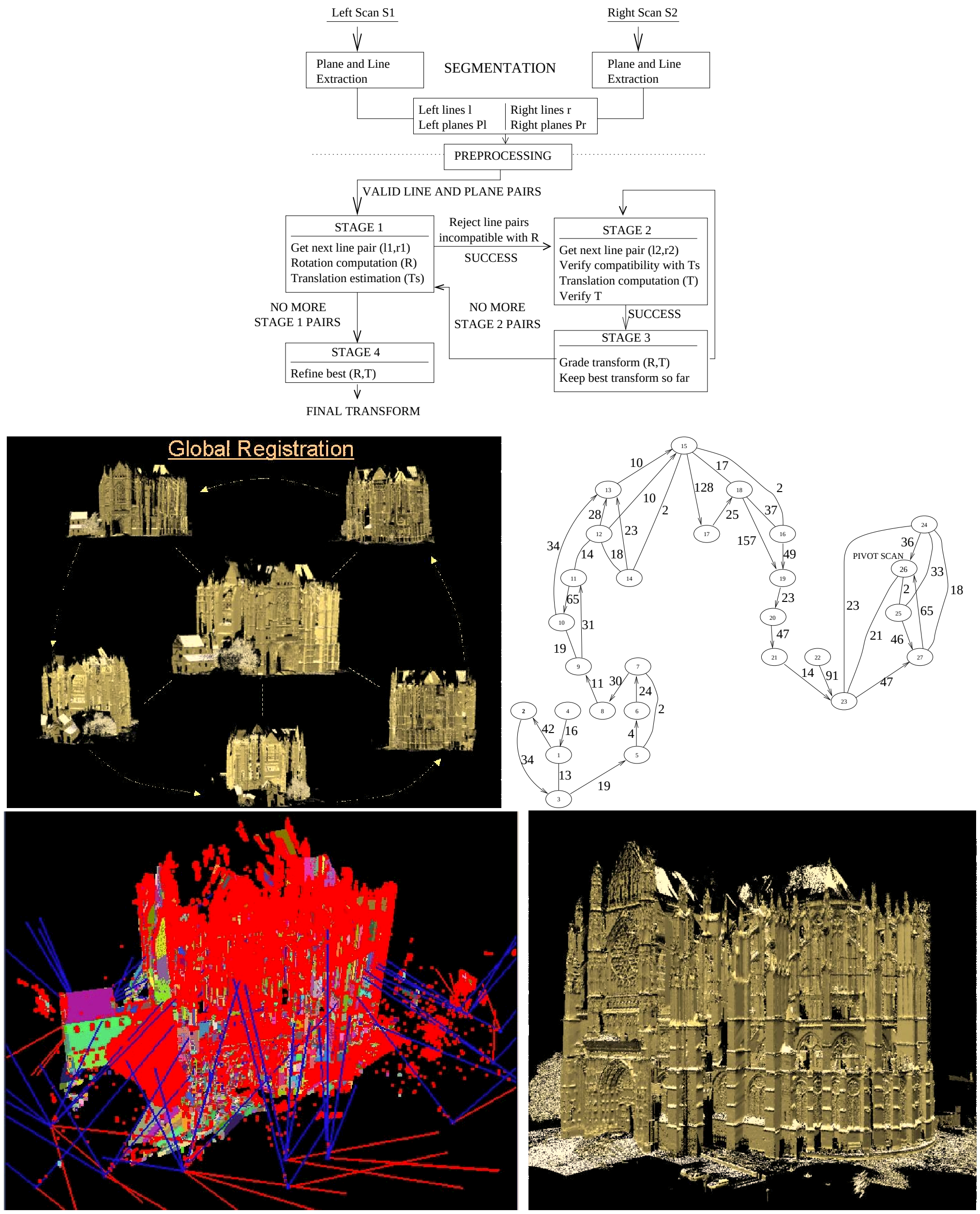

Figure 1: Top: Flowchart for automatic registration between a pair of overlapping range scans. Middle: Global registration problem. We need to correctly register all scans of the Cathedral using a Graph of 27 registered scans of the Cathedral data-set. The nodes correspond to the individual range scans. The edges show pairwise registrations. The weights on the edges show the number of matched lines that the pairwise registration algorithm provides. The directed edges show the paths from each scan to the pivot scan that is used as an anchor. Bootom Left: 3–D mesh after 27 scans has been placed in the same coordinate system. Segments used in the registration are shown colored. The local coordinate system of each individual scan is shown. The z-axis of each scan points towards the Cathedral. Bottom Right: Model of Cathedral of St. Pierre, Beauvais, France registerd using 47 range scans