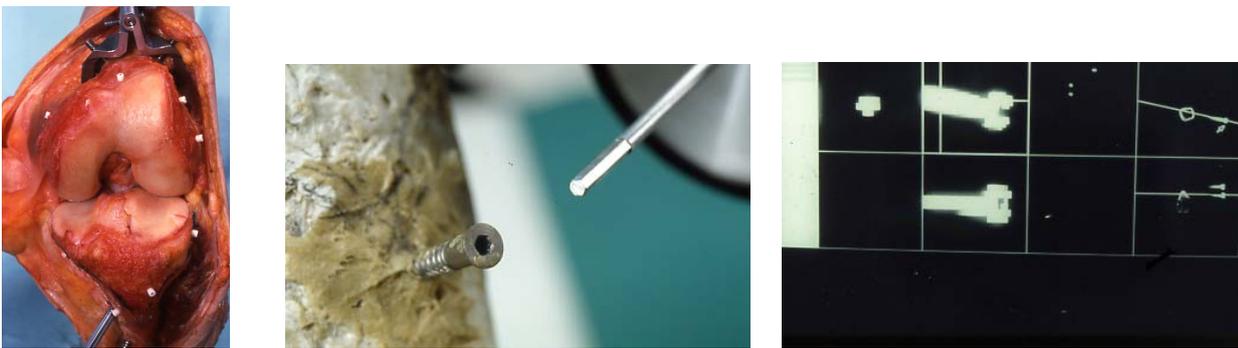


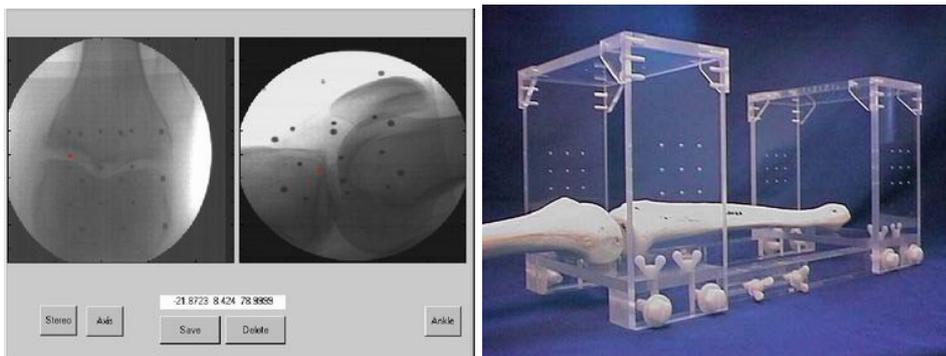
Minimally Invasive Registration

Computer Assisted Surgery (CAS) is concerned with the improvements achievable by using computers and technological devices in planning and executing surgical interventions. The registration of different coordinate frames, often achieved through the matching of 3-D data sets, represents a crucial step in most CAS applications.

First registration procedures were invasive and consisted in the application on the bones of markers before image acquisition. These markers were used for a point to point matching between image and patient.



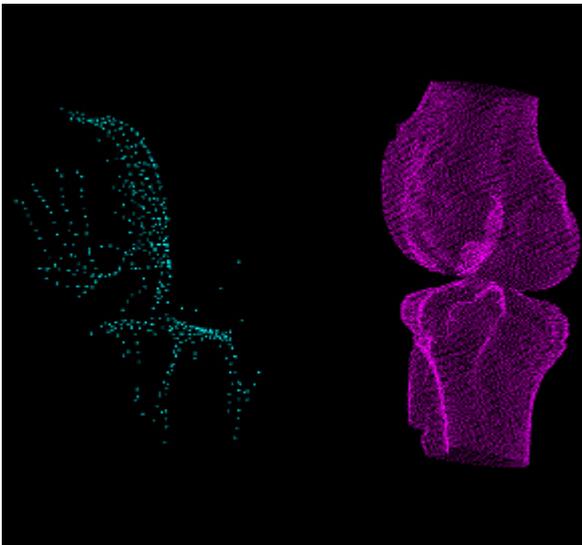
The use of non-invasive or minimally invasive registration procedures is regarded as a necessary step towards the optimisation of CAS protocols. Different approaches have been investigated and validated to attain this target



A first solution concerns a fluoroscopy-based CAS system. In this application, one or two pairs of 2-D fluoroscopic scans, representing different views of the same anatomical segment, are registered using a projective calibration algorithm. A plexiglas cage equipped with stainless steel markers is used to have a common reference in all the images

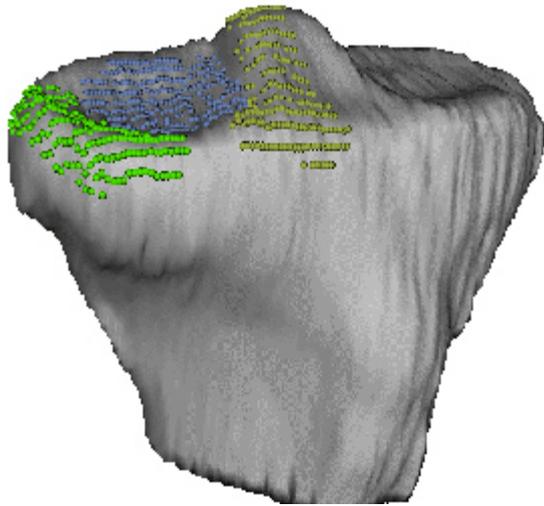
Accuracy tests performed on phantom bones gave satisfactory results.

A second approach is a minimally invasive registration technique based on the "Iterative Closest Point" (ICP) algorithm. Such approach was conceived for two specific CAS applications: a computer and robot assisted system for total knee arthroplasty (TKA) and an augmented reality navigation system for computer assisted minimally invasive surgery of the knee. In the first application the algorithm is used to match two "cloud-of-points" representations of the bones, one deriving from a CT-based preoperative model and the other from an intraoperative acquisition by means of a precision digitiser



The procedure has been extensively tested on phantom bones, animal and cadaveric specimens and proved to have an accuracy of about $2^\circ / 2\text{mm}$.

In the second application a more refined technique named "area-constrained ICP" is used to match a "cloud of points" digitised intraoperatively with a triangular mesh representation of the preoperative model



Points are forced to stick to pre-defined areas, hence the denomination. This registration protocol has been devised for surgical procedures in which bones are barely accessible with the digitiser. Preliminary trials show that the accuracy is around 3°/3mm.