Summary of thesis:

“Reduction of registration error between patient’s position and preoperative anatomical model in minimal invasive abdominal surgery interventions.”.

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The subject of this thesis is reduction of registration errors between a patient’s position and the preoperative anatomical model in minimal invasive abdominal surgery interventions, that occur in navigation systems. These systems enable the usage of anatomical information (in most cases from a preoperative anatomical model, created from layered images) in order to increase the accuracy and decrease the time required to localize a tumor during the surgical interventions. To achieve this goal, navigation systems are continuously localizing markers positioned on the patient's skin via an optical tracking system. These positions and the localizations of radiological markers in the anatomical model’s coordinate system are input to the registration algorithm, which computes the transformation between those two coordinate systems. The obtained transformation could be used to calculate the position of surgical tools in the operating room, in reference to the anatomical model. An important task of the system is to estimate the movement and deformation of organs, caused by breathing, which increases registration errors during the intervention.

The goal of the thesis is achieved by designing a patient record that is able to store all information required for registration. Furthermore, algorithms which are able to estimate the deformation field are integrated. The thesis was focused on two of them: Thin Plate Spline (TPS) and Elastic Body Spline (EBS). Additionally, a new approach is presented, where adjustment of EBS parameters by Particle Swarm Optimization (PSO) algorithm is introduced. Moreover, all required parts of the navigation system are integrated and clinical tests are performed. The results are used to verify the previously stated hypothesis. Finally a real time error visualization tool is designed and implemented.

Based on the results of experiments carried out on 17 patients, a comparison of the following registration techniques is done: rigid registration, affine registration, TPS, EBS and EBS with PSO optimization. Statistical hypothesis verification by ANOVA test method is perfomed. With an assumed significance level (set to 0.05), the method introduced in this thesis (EBS PSO) gives significantly better results than other methods and registration errors are decreased.