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Pose Recovery of Intramedullary Nail Distal Hole Using Neural Networks

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Orthopedic surgery is an important treatment concerned with injuries, trauma and other disorders of the musculoskeletal system. Closed Intramedullary Nailing (IMN) of Femur is one of the most frequently used treatments in orthopedics. It has developed into a common method of treatment for femoral shaft fractures. A procedure of fixation named "distal locking" requires a fluoroscopic monitoring for screw locking process. Currently, in this conventional distal hole locking, it uses trial-and-error method to find a correct projected path for inserting the screws. This requires high experience and a numerous x-ray images for randomly adjusting the fluoroscope direction. According to this gradually adjustment, a high amount of radiation scattered to the primary surgeons and patients has been reported in several orthopedic investigation. The concept of the proposed study is to utilize a computer-integrated surgery (CIS) method to guide a surgeon for recovering the correct position and orientation (or "pose") of the intramedullary nail. The algorithms emphasize on using a neural network approach to recognize and provide rotation angle of the intramedullary nail relative to the image intensifier (fluoroscopic system).

Overall study in x-ray image projection of the distal holes, there are two main possible cases of the obtained images. First, it occurs when the plane of the fluoroscope or C-arm is perpendicular to the nail axis while taking x-ray. Therefore, the distal hole projections can be investigated approximately for only in one axis, "Nail Axis." The other case happens when the C-arm's plane is not perpendicular to the nail axis. Therefore, the distal hole projection images are the combination of various rotation angles' axis. This analysis has to be performed on a Z-Y-X Euler Angle which is much more complex than the first case. With several utilities of neural networks, various applications employ this knowledge to solve many problems including in medical aspect. Artificial neural networks is one of the effectively techniques that performs in various works, for examples, in pattern recognition, optimization problems, control techniques and so forth for last decade.

In this study, the neural network has been learned about the distal hole projection images in the first case study. A certain series of 2-D images has been fed into an input layer of a multilayer perception network which is operated by back prorogation learning algorithm. Basically, these images are the indifferent in rotation angles of the nail. The significant essence of the images is the shape of distal holes which are both in ellipse and circular shapes. All images have been employed by pre-processing module for extracting important parameters beforehand. Subsequently, sigmoid neuron units in hidden layer have been trained and updated their weights during the learning procedure. A number of output neural units are the same as a number of rotation angles which are fed into the input layer. The appropriate network architecture has been selected by cross-validation approach which is divided a data set into training set and test set. After that the test data set has been loaded in order to verify the generalization ability of the network.

According the preliminary results, the experiment was performed and analyzed accuracy. The rotation angle results which were recognized by the efficient neural network have been measured with respect to the real world orientation. The rotation accuracy is satisfied with acceptable errors for providing the orientation information to the guided system. The pose recovery is obtained using only 2 x-ray projection images. This obtained rotation angle together with the translation vector will be formed a transformation matrix. This information will advise the direction of fluoroscopic system in order to finding the appropriated distal holes of the intramedullary nail. Future task of this study is to mention on the non-perpendicular between the C-arm's plane and the nail's axis. The training data will be a combination set of the Z-Y-X Euler Angle. The x-ray images are displayed in a shape with more than one rotation axis. It will compose of rotation in x-, y-, and z-axis. Moreover, the experiment will be performed the generalization ability of the neural network for different data set of the patients.