# HipSurve: A Machine Learning Approach toward Hip Surveillance and Clinical Outcome Prediction for Cerebral Palsy Patients

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INTRODUCTION:

Hip displacement is the second most common orthopaedic condition in children with cerebral palsy (CP). This condition occurs in 1 in 3 children with CP and may cause pain and disability. Hip displacement occurs because muscular imbalances generate abnormal forces across the hips. Over time, this causes the head of the femur to subluxate from the acetabulum. We have developed a methodology for automated hip landmark annotations to determine migration percentage (MP) using deep learning.

METHODS:

Data was collected from 53 children with CP between 3-8 years old who presented to our medical facility between years 2008 and 2020 and received x-rays of hips in the anterior posterior view. Individual anonymized x-rays were cropped to include the region of interest, where 8 landmarks (2 on the head of each femur and 2 on each acetabulum) would be placed. After augmentation (brightness adjustment, random rotation from 0° to 10°, horizontal flip, shift of widths and heights), a total of 980 scans were used to develop this algorithm (90% for training and 10% for validating). All cropped images were resized to 512 x 512 pixels and annotated. A deep learning algorithm was trained with hip x-rays and landmark coordinates as inputs. The model was coded in Python using the Keras library and a TensorFlow backend. Once the trained model annotated the landmarks on the x-rays, we developed a geometric algorithm to find MP. Using predicted landmarks, we wrote the equation for Hilgenreiner's and Perkin's lines and calculated the angle formed between Hilgenreiner's and the horizontal lines of the scan. The x-ray was rotated by θ, the MP value is the ratio of the distance the femoral head migrated (α) and the total width of the femoral head (β)on the rotated scan.

RESULTS:

Our trained model has a validation accuracy, mean squared error, and mean absolute error of 0.96, 0.00067, and 0.017, respectively. Due to the small data size, using a pre-trained neural network speeds up the process of learning with faster convergence. Once the correct landmarks are identified, our geometric algorithm presents the MP value, which can be used by clinicians for hip surveillance.

DISCUSSION AND CONCLUSION:

We have developed an automated algorithm for landmark prediction on hip x-rays using a deep learning approach. These landmarks are used by our MP calculation algorithm to help clinical experts evaluate the need for surgical intervention.

Hip x-rays are easy to acquire, however regular clinics tend to lack the clinical expertise required to evaluate the need for orthopaedic consultations. Our proposed method would help in automatically triaging children who need clinical intervention based on the MP value.

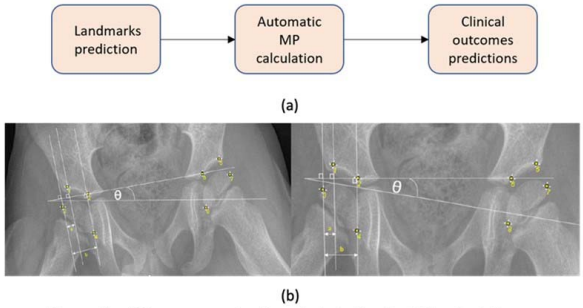


**Figure 1:** a) The proposed automated pipeline for MP calculation
b) our proposed algorithm for MP calculation using the landmarks.