# THA-AID: Deep Learning Tool for Total Hip Arthroplasty Automatic Implant Detection with Uncertainty and Outlier Quantification

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INTRODUCTION:
Successful and efficient revision total hip arthroplasty (THA) requires accurate implant identification that can be challenging and time-consuming. Deep learning (DL) methods have been proposed to perform this automatically, however, current work is limited by few femoral implants and none have been able to detect acetabular components and none have an inability to quantify model certainty and detect outliers from the training dataset. This study introduces THA-AID, a DL model that addresses all these constraints.
METHODS:
We built a 5-fold cross-validation DL classifier to recognize 8 acetabular and 20 femoral implants from 24,248 AP, cross-table lateral, and oblique radiographs obtained from 13,375 patients. A Mondrian Cross-Conformal Predictor (MCCP) was fit to return predictions with percentage certainty for multiple possibilities adding up to 100%. An outlier detector was built to recognize implants unseen during training. The model was assessed against an external center test set.
RESULTS:
The model classified internal test set femoral and acetabular components with 98.8% and 98.7% accuracy, respectively, and external test implants with 98.0% accuracy. There was significant decrease in performance between radiographic view. MCCP coverage (fraction of prediction sets with true labels) and efficiency (fraction of prediction sets with a single label) were 99.6% and 82.6% (tolerable error rate=1%) for femoral classification, and 98.4% and 40.7% (2.5%) for acetabular classification, respectively. MCCP had 98.2% coverage and 90.6% efficiency for classifying external set implants. The outlier detector identified >99.4% of outliers from out-of-domain datasets.
DISCUSSION AND CONCLUSION:
THA-AID is a DL tool with clinical promise for providing trustworthy and explainable classification of THA implants. The model builds on prior efforts by providing a percentage certainty and multiple options in the face of uncertainty, performs equally well on various radiographic views, includes a large number of femoral implants, and is the first to classify acetabular components.