Radar imaging has revolutionized target detection and recognition, providing precise and high-resolution information about objects, enabling reliable identification and tracking across diverse and challenging environments. ISAR (Inverse Synthetic Aperture Radar) is a radar imaging technique that uses the relative motion of targets and the radar system to produce high-resolution target images. Automatic Target Recognition (ATR) has improved surveillance and reconnaissance operations across different sectors.  Extensive studies within the field have explored the use of ISAR for ATR, with remarkable outcomes. Deep learning algorithms that use Convolutional Neural Networks (CNNs) have shown extraordinary performance in target recognition and classification. The project intends to investigate the relationship between network complexity and classification accuracy by thoroughly examining and validating the performance of three well-known CNNs—GoogleNet, AlexNet, and LeNet5—using a simulated dataset. The three networks, LeNet, AlexNet, and GoogleNet, demonstrate a spectrum of increasing complexity, allowing testing to determine whether more elaborate structures enhance target classification accuracy. Two verification methods are created: one to analyze the overall performance of the three networks and the other to test their performance when given fewer target features. The results show a relationship between network complexity and classification accuracy with a little performance difference between Lenet5 and AlexNet, but GoogleNet, a much more complicated network, outperforms both. Finally, a custom CNN is built and evaluated for specific classification problems to aggregate the investigation's findings. The network is developed based on the simplicity of Lenet5 with added features from other networks that are believed to improve performance.