Photographing small objects with a quadcopter is non-trivial to perform with many common user interfaces, especially when it requires maneuvering the Unmanned Aerial Vehicle (UAV) to difficult angles in order to shoot high perspectives. The aim of this research is to employ machine learning to support better user interfaces for quadcopter photography. Human Robot Interaction (HRI) is supported by visual servoing, a specialized vision system for real-time object detection, and control policies acquired through reinforcement learning (RL). Two investigations of guided autonomy were conducted. In the first, the user directed the quadcopter with a sketch-based interface, and periods of user direction were interspersed with periods of autonomous flight. In the second, the user directs the quadcopter by taking a single photo with a handheld mobile device, and the quadcopter autonomously flies to the requested vantage point. This dissertation focuses on the following problems: 1) evaluating different user interface paradigms for dynamic photography in a GPS-denied environment; 2) learning better Convolutional Neural Network (CNN) object detection models to assure a higher precision in detecting human subjects than the currently available state-of-the-art fast models; 3) transferring learning from the Gazebo simulation into the real world; 4) learning robust control policies using deep reinforcement learning to maneuver the quadcopter to multiple shooting positions with minimal human interaction.