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An Application of Convolutional Neural Networks to Aircraft Ejection Seat Testing

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Abstract

The testing of aircraft ejection seats has been an important aspect of testing in the aerospace industry for several decades. Identification and tracking of aircraft ejection seat systems, during field testing, has practical benefits in post-test analysis and real-time tracking applications. This paper proposes a methodology to identify and locate ejection seat systems in a video stream as they are propelled from a dynamic aircraft test bed. The field testing environment is cluttered with natural and man-made artifacts that effect the background appearance and make the video stream data visually noisy. The identification problem involves the extraction of critical information from the video stream and feeding it into a deep learning convolutional neural network that determines the location of the ejection system within the field of view. The results achieved, using the convolutional neural network to identify features of the ejection seat system, were promising. In particular, the convolutional neural network demonstrated an ability to identify objects that were in a different spatial orientation (rotation) than were used to train the network.

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Keywords: Convolutional Neural Networks; Object Identification; Image Processing; Escape Systems

1. Introduction

Since the advent of modern jet powered flight, crew safety has been of significant importance. Crew escape technology has progressed from simple parachutes to highly sophisticated ejection seats and escape pods capable of

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negotiating harsh environmental extremes to safely return pilots and crews to the ground from crippled aircraft. The US Dept. of Defense spends significant time and effort testing ejection seat escape systems to ensure that the crews of modern military aircraft have a significant probability of survival should the need arise.

The US Dept. of Defense performs demonstration testing on ejection seat systems in near realistic conditions. High speed test facilities, such as the Holloman High Speed Test Track [1], use rocket-powered sleds to accelerate test articles to velocities that approximate flight conditions. Crew ejection seat systems have been tested at sled velocities ranging from 0 ft/sec to over 1000 ft/sec [2]. Video data collected during the tests is used for performance analysis and validation of the ejection seat systems.

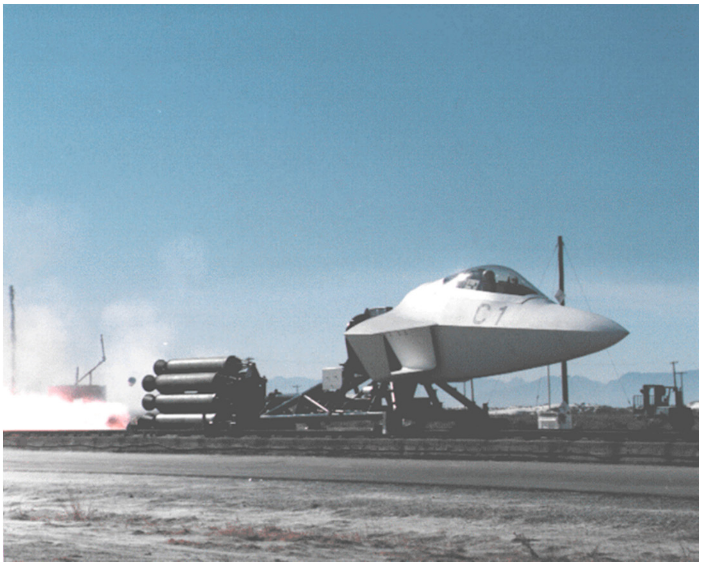

Figure 1: F-22 Rocket Sled Test Bed

The inherent complexity of the items under test, and the test environment, can make object identification within the video stream difficult. The object of interest is transformative and changes as the test progresses. Initially, the object of interest is the rocket sled itself as the test bed is accelerated to test velocities. When the sled has achieved the proper test conditions, the object of interest changes to the pilot/ejection seat system. The pilot/ejection seat system is the object of interest as it transitions from being a component of the sled test bed to a dispensed dynamic projectile. The object of interest changes again as the pilot/ejection seat system splits into two objects, the ejection seat itself and the manikin that represents the human pilot in the system.

a) 

b) 

Figure 2: Object of Interest at different test phases a) sled / ejection seat system separation b) manikin / seat separation

The test environment is also very complex as it is comprised of natural and man-made artifacts that may disguise or camouflage the object of interest. Natural artifacts may include changing landscapes, flora and on rare occasions fauna. Man-made artifacts may include buildings, vehicles and test equipment structures. The combination of high test velocities, dynamic test conditions, natural landscape and man-made artifacts results in a very noisy and cluttered environment.