ESPRIT: EXERCISE SENSING AND POSE RECOVERY INFERENCE TOOL
FOR CREW EXERCISE MONITORING

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INTRODUCTION
Crew exercise is important for maintaining health and fitness of astronauts, especially in preventing adverse health problems associated with long-duration space flight, such as losses in muscle strength and endurance, bone density, balance and aerobic capacity. Monitoring of crew health and fitness is therefore important, and this includes performing motion capture and kinematic analysis to understand the effect of microgravity on exercise, and ensure that the exercise prescription (ExRx) is effective.

We propose an exercise monitoring system called ESPRIT: Exercise Sensing and Pose Recovery Inference Tool. This is a stereo camera system that monitors exercise activities, detects markers placed on the body, extracts image features, and recovers 3D kinematic body pose. ESPRIT uses strong prior knowledge and modeling of human body, pose, dynamics, and appearance. It uses advanced statistical inference techniques to achieve robust and accurate motion capture. Preliminary lab result has been promising and has demonstrated motion capture of several exercises, including walking, curling and dead lifting.

APPROACH
The key innovations of the ESPRIT system are: (1) a composite human body model that provides statistical priors on body shape, size, and appearance (2) extraction of human silhouette patterns and combining it with marker features to provide feature cues for pose estimation. (3) A robust and efficient marker detection algorithm with sub-pixel accuracy for extracting good depth estimation from stereo. (4) A statistical sampling-based method, Markov chain Monte Carlo (MCMC) [1], is used to compute a global optimization of the human pose trajectory, using multiple cues in addition to markers. This helps to overcome temporary visual ambiguity due to partial occlusion.

ESPRIT addresses the robustness issue of pose estimation from a stereo camera. By using multiple feature cues and statistical inference techniques, it removes the need for multiple distributed cameras. With a stereo camera, the hardware footprint of the system is small, in terms of size, weight, power consumption, and setup time.

RESULT AND CONCLUSION
Preliminary result of ESPRIT software prototype on a ground lab environment has been promising. Using a commercial stereo camera system, we have demonstrated the feasibility of motion capture of several exercises, including treadmill walking, curling and dead lifting (see Fig.). For measuring relative locations of markers, an average accuracy of about 10mm was achieved. With further changes in the hardware design and algorithm enhancements, it is projected that an accuracy of 5mm or less can be achieved in near future.

The ESPRIT system will support NASA’s Exercise Countermeasure program for observing crew’s exercise, performing motion capture and kinematic analysis. ESPRIT is designed to satisfy the constraints in size, weight and power consumption imposed by the ISS environment. The system will be easy to set up and operated by the crew.

REFERENCES