Representation of the Physiological Factors Contributing to Postflight Changes in Functional Performance Using Motion Analysis Software

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Abstract: Astronauts experience changes in multiple physiological systems due to exposure to the microgravity conditions of space flight. To understand how changes in physiological function influence functional performance, a testing procedure has been developed that evaluates both astronaut postflight functional performance and related physiological changes. Astronauts complete seven functional and physiological tests. The objective of this project is to use motion tracking and digitizing software to visually display the postflight decrement in the functional performance of the astronauts. The motion analysis software will be used to digitize astronaut data videos into stick figure videos to represent the astronauts as they perform the Functional Tasks Tests. This project will benefit NASA by allowing NASA scientists to present data of their neurological studies without revealing the identities of the astronauts.

Introduction

Exposure to microgravity during spaceflight causes differences in the physiological systems of the astronauts. The sensorimotor disturbances, cardiovascular deconditioning, and loss of muscle mass and strength, leads to the astronauts' temporary inability to execute functional tasks once they have returned to a gravitational environment (Earth). NASA scientists in the Neurosciences Laboratory at the Johnson Space Center, are studying the main factors that contribute to changes in performance of a set of functional tasks that are representative of critical mission tasks for lunar and MARS operations. The set of functional tests making up the Functional Task Tests (FTT) include the: 1) Seat Egress and Walk Test, 2) Ladder Climb Test, 3) Recovery from Fall/Stand Test, 4) Rock Translation Test, 5) Jump Down Test, 6) Torque Generation Test, and 7) Construction Activity Board Test.

Given that astronauts may be required to jump down from landing vehicles or habitats, and walk on uneven terrains during exploratory extravehicular activities (EVAs), NASA scientists have designed functional tests to investigate the astronauts' walk and jump performance. During the Line-test, subjects are required to walk a straight line with their feet tandem to one another (heel-to-toe). The subjects' arms must be folded across the chest and eyes must be closed. This test is repeated for a total of 3 trials. The Jump Down Test, a functional test that investigates jump performance, was designed because astronauts have shown alterations in their ability to perform a voluntary two-footed downward jump. During the Jump Down test, subjects will use a two-footed jump from a height of 30 cm and land on a force plate. The test is also repeated for a total of 3 trials.

The Functional Tasks Tests are administered a total of seven times: 180 days before launch, 60 days before launch, 30 days before launch, the day of return, 1 day after return, 6 days after return, and 30 days after return. However, in order for NASA scientists to present the results of their studies, they must do so in a way that will protect the privacy of the astronauts that are tested.

The video-based motion analysis software, MaxTRAQ, was used to digitize astronaut data videos. This software allowed the manual tracking of the subjects' movement, frame by frame. Once the videos had been completely tracked, the coordinates were put into MatLab, which in turn, generated stick-figure videos.

Materials and Methods

Line-Test Digitization. Functional Task Tests data videos of a Shuttle crew subject were obtained. The subject's line test videos were then converted from MOV files to AVI files. After importing the AVI files to MaxTRAQ, the subject's line test on the day of the Shuttle's return was digitized frame by frame. First, fifteen points on the subject's body were selected and labeled the following: head, neck, light wrist, left elbow, left shoulder, right shoulder, right elbow right wrist, left toe, left ankle, left knee, pelvic, right knee, right ankle, and right toe. Then, two points on the line were selected and labeled start and finish. The points were then connected in the appropriate areas to a make a stick figure and a line. The previous three steps were repeated for each frame.

Jump-Test Digitization. Data videos of the same subject's jump test were also obtained, converted to AVI files, and imported into MaxTRAQ. The videos of the subject's first jump on the day of the Shuttle's return was then digitized frame by frame by first selecting the same fifteen body points, but then selecting and labeling eight base points on the testing apparatus. As with the line-test, the points were then connected in the appropriate areas to a make a stick figure but also the jump-test apparatus and repeated for each frame.

Data videos of a different Shuttle crew subject's jump test were also obtained, converted to AVI files, and imported into MaxTRAQ. The videos were also of the subject's first jump of the day of the Shuttle's return and was digitized by selecting the same fifteen body points, but then selecting and labeling ten base points. The points were then connected in the appropriate areas to a make a stick figure and jump-test apparatus and repeated for each frame.

After each video has been completely digitized the video was saved as an ASCII file, and the coordinates of the points are imported into MatLab, data-analysis software. The MatLab program then used the coordinates to generate stick-figure videos.

Results and Discussion

The digitized videos of both the line-test and the jump-test of the first subject were unsteady and jumpy because of three reasons: 1) the original video was downsampled to 10 frames per second for the sake of reducing the labor and speeding up the point selection process; 2) the camera was not mounted on a tripod and was prone to operator-induced perturbations; and 3) there were no markers on the subject, so there was some amount of guesswork in selecting some of the stick points.

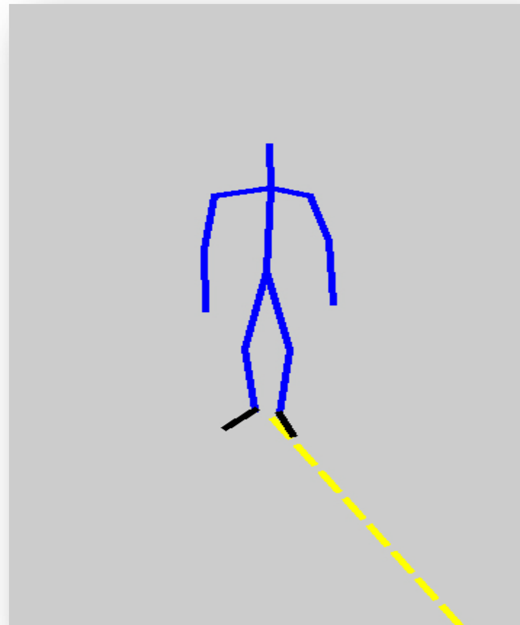

Figure 1: Line-test of first subject.

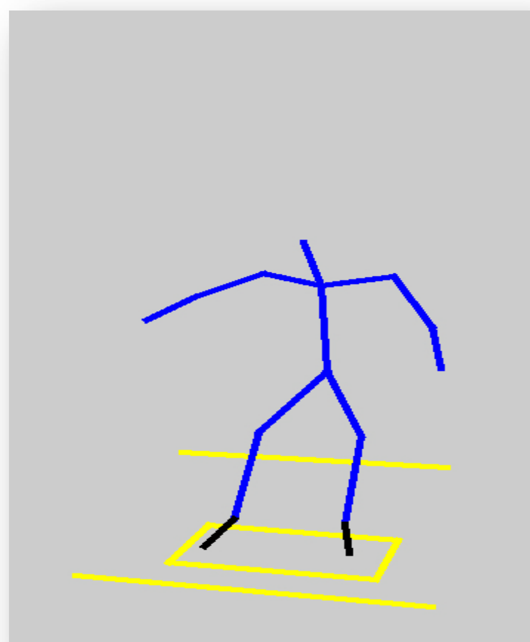

Figure 2: Jump down test of first subject.

However, after learning more about the MaxTRAQ software, and better techniques of digitizing the videos, I was able to digitize the videos more quickly and accurately. The digitized videos of the second subject's jump-test were smoother and more accurate movements.

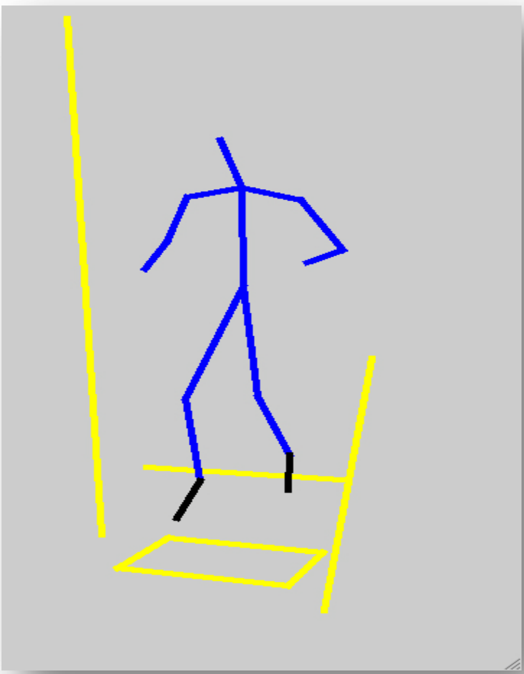

Figure 3: Jump down test of second subject.

Future Testing

Before beginning the FTT testing, markers need to be placed on the subjects in 15 locations (head, neck, right wrist, right elbow, right shoulder, left shoulder, left elbow, left wrist, right toes, right ankle right knee, middle of waistline, left knee, left ankle, and left toes). Depending on the complexion of the subjects' skin, either white or black markers should be used. Therefore, the markers used should be small Styrofoam spheres that are white in color and some should also be painted or colored black. The wall behind the testing apparatus will need to be covered with either the white or black coverings. If white markers are used, then the black cover should be used, and vice versa. The opposing colors will created a high contrast that the will be easily recognized by the auto-tracking software. During the testing, the camera needs to be fixed on a tripod to eliminate operator-induced movements. The camera position should be place on the side, on the side slightly to the front, and in the front, depending on which test is being administered. For example, if the Jump-test is being administered, then the camera should be positioned on the side, slightly to the front, but if the Line-test is being administered, then the camera should be positioned in front of the subject. After the FTT testing has been completed, testing video will be auto-tracked using the same software (MaxTRAQ). The videos will then be converted to stick-figure videos.

Conclusion

Because exposure to microgravity during spaceflight causes variation in the physiological systems of the astronauts, scientists are currently studying the physiological factors that contribute to these changes in performance. Astronauts are being tested on a set of functional tasks that are representative of critical mission tasks for lunar and MARS operations. However, in order for NASA scientists to present the results of this study, they must do so without revealing the identities of the astronauts. Therefore, my project this summer entailed utilizing video-based motion analysis software to digitize Functional Tasks Tests video data, turning the astronauts into stick figures. After digitizing the videos frame by frame, some of the movements were not as smooth as others due to the downsampling of some videos, camera operator-induced perturbations, and the manual selection of points. For future FTT testing, high contrast markers will be placed on the subjects so the data videos can be auto-tracked using the same software.

Acknowledgements

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TEXAS SOUTHERN UNIVERSITY

Greenville
Heart & Soul of the Delta

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Texas Southern University

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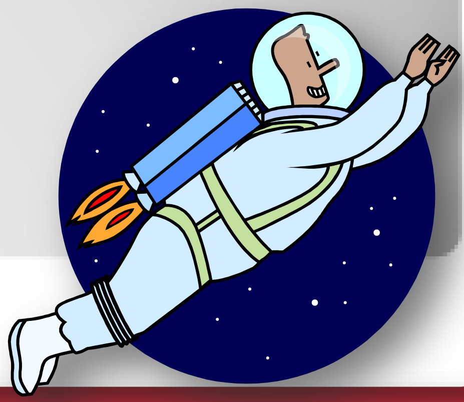
Future Goals

- M.S. in Biology, May 2012
- Apply to Medical School, Fall 2012
- Ph.D./M.D.

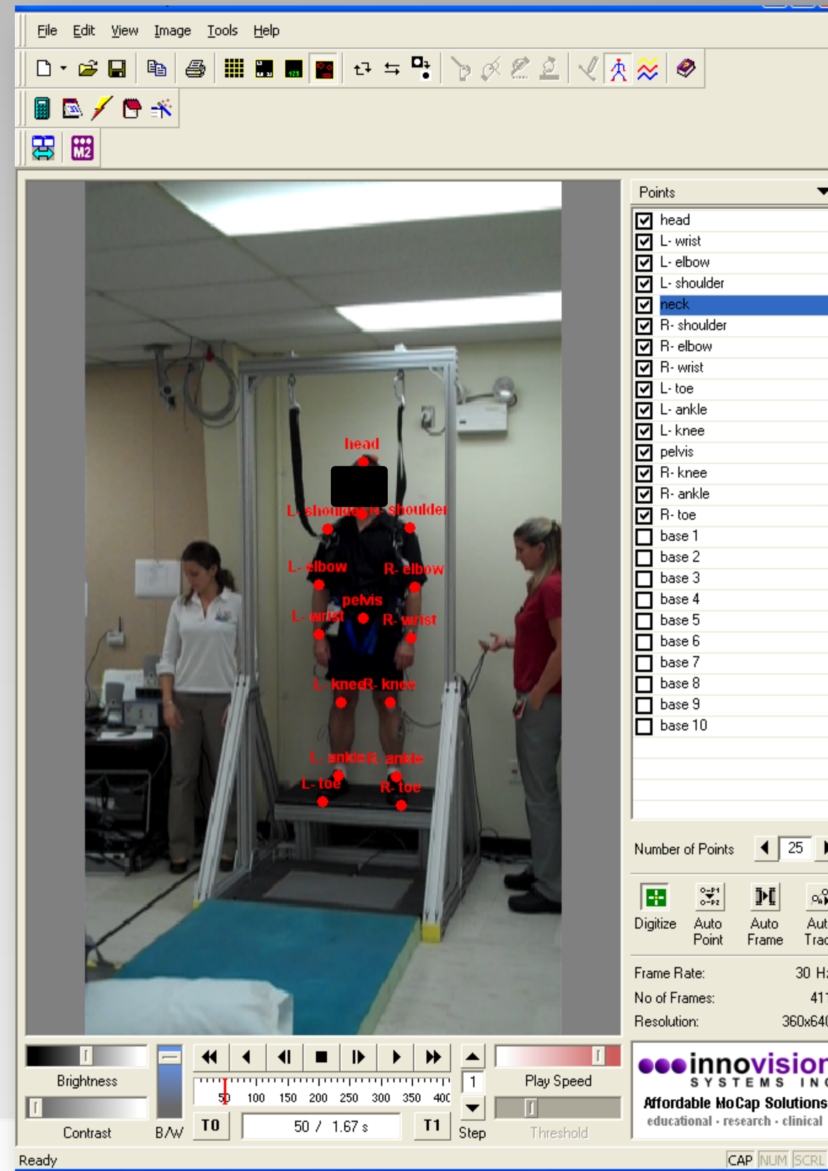
About Me

- Exposure to microgravity during spaceflight causes differences in the physiological systems of the astronauts.
- Neurosciences Laboratory is studying the main factors that contribute to changes in performance through a set of functional tasks that are similar to mission tasks for lunar and MARS operations.
  - Line-Test
  - Jump Down Test
- In order for NASA scientists to present the results of their studies, they must do so in a way that will protect the privacy of the astronauts that are tested.
- The video-based motion analysis software, MaxTRAQ, was used to digitize astronaut data videos.



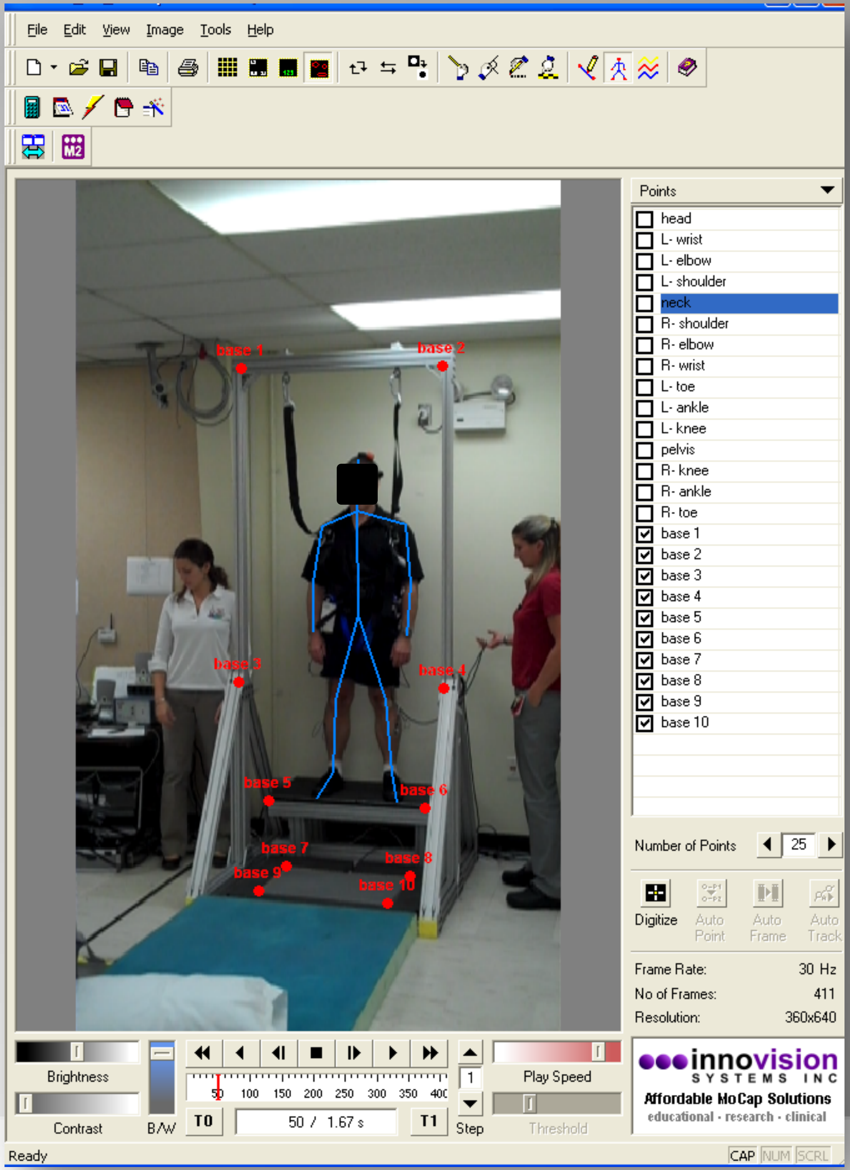
Introduction

- Collected FTT data videos.
- Converted videos to AVI files and imported to MaxTRAQ.
- Selected and labeled points on the subject’s body.



Procedure

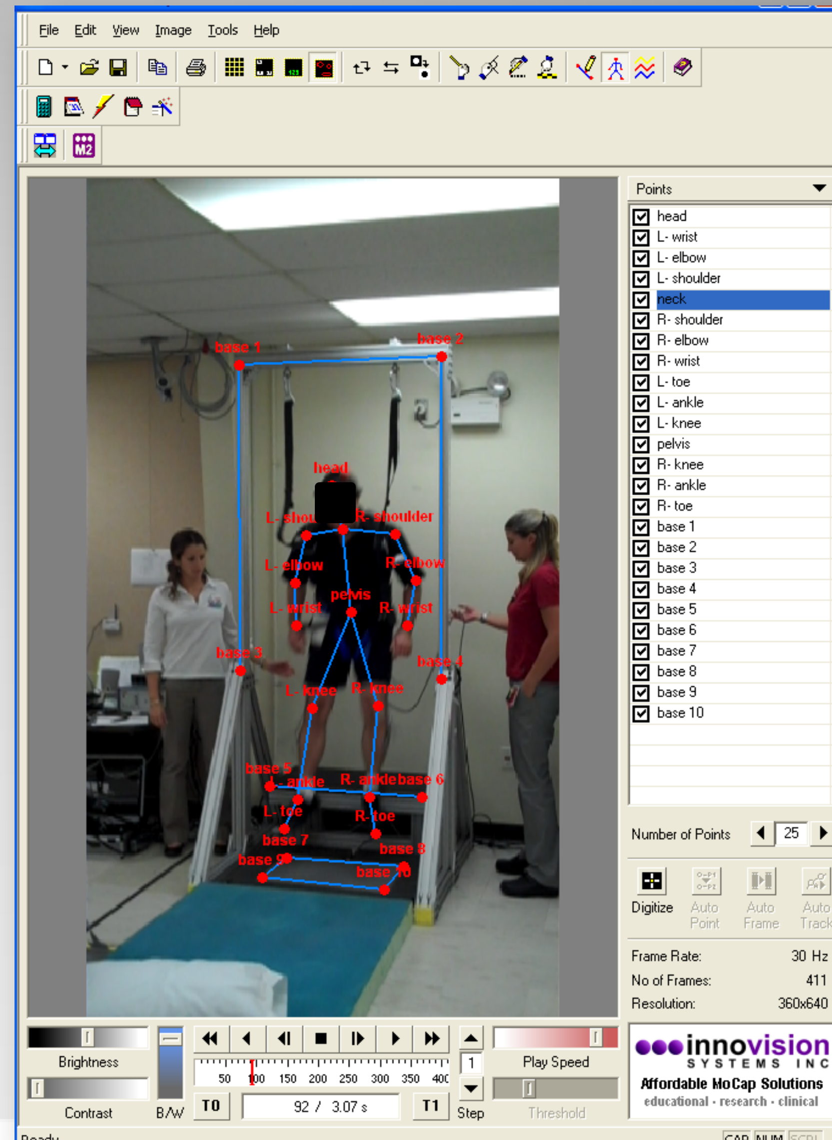
- Selected and labeled points on the testing apparatus.
  - Line-Test: start and finish
  - Jump-Test: points on the base

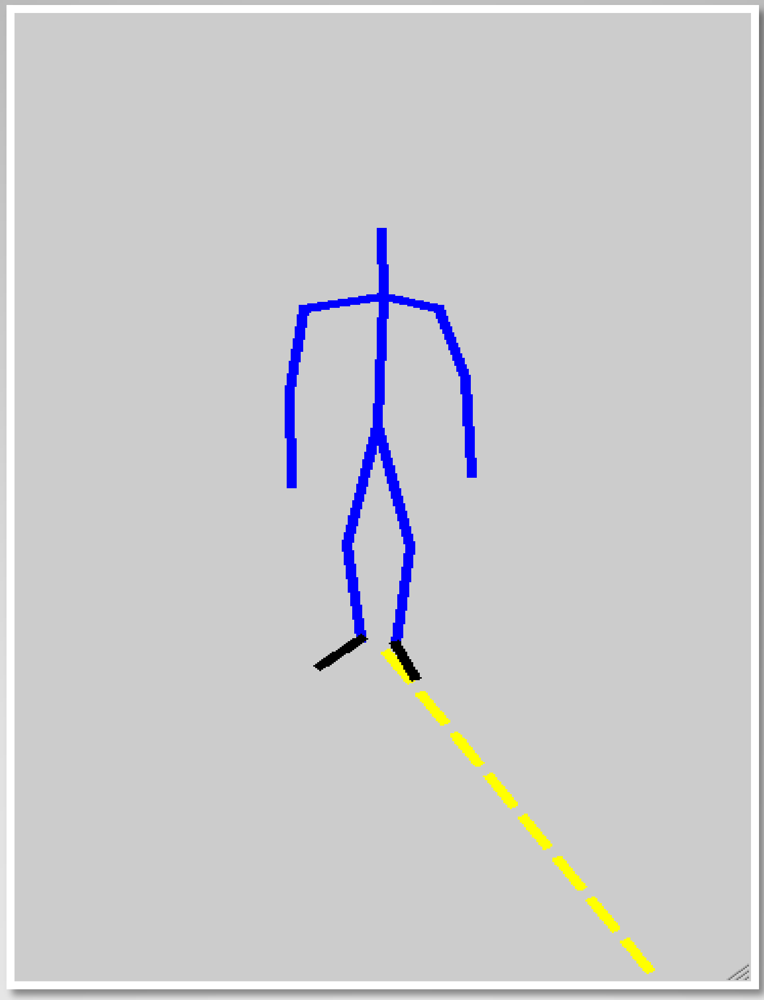


Procedure

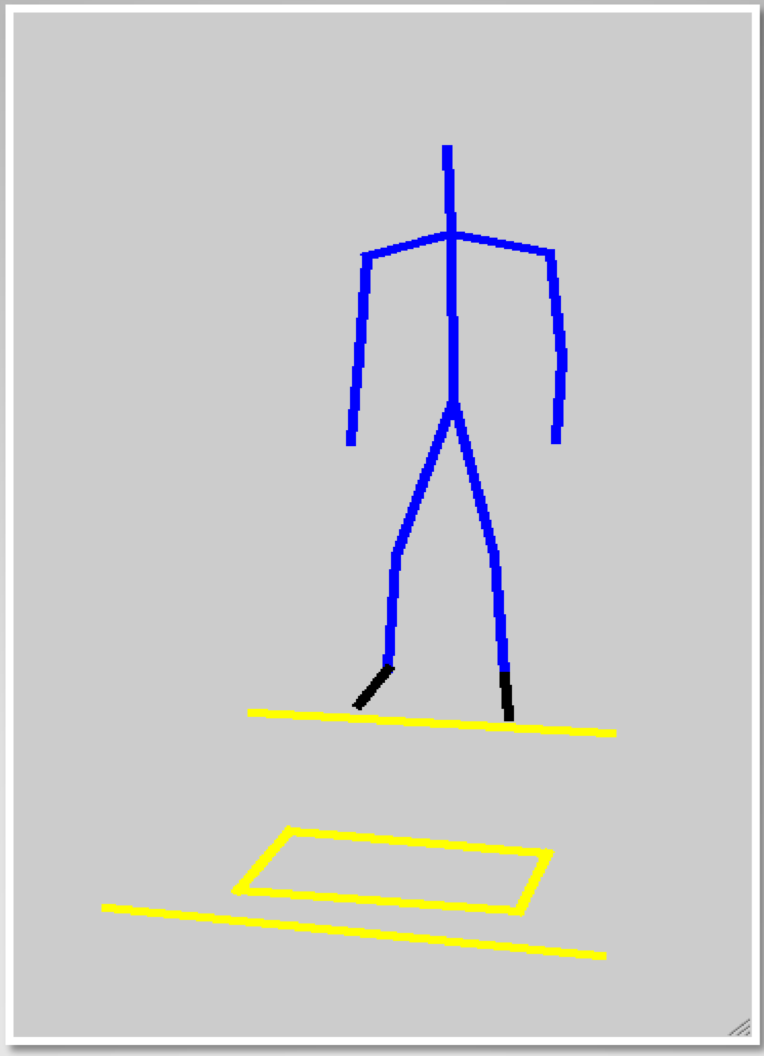
Procedure

- Connected points in the appropriate areas to a make a stick figure.
- Coordinates were then exported to MatLab.



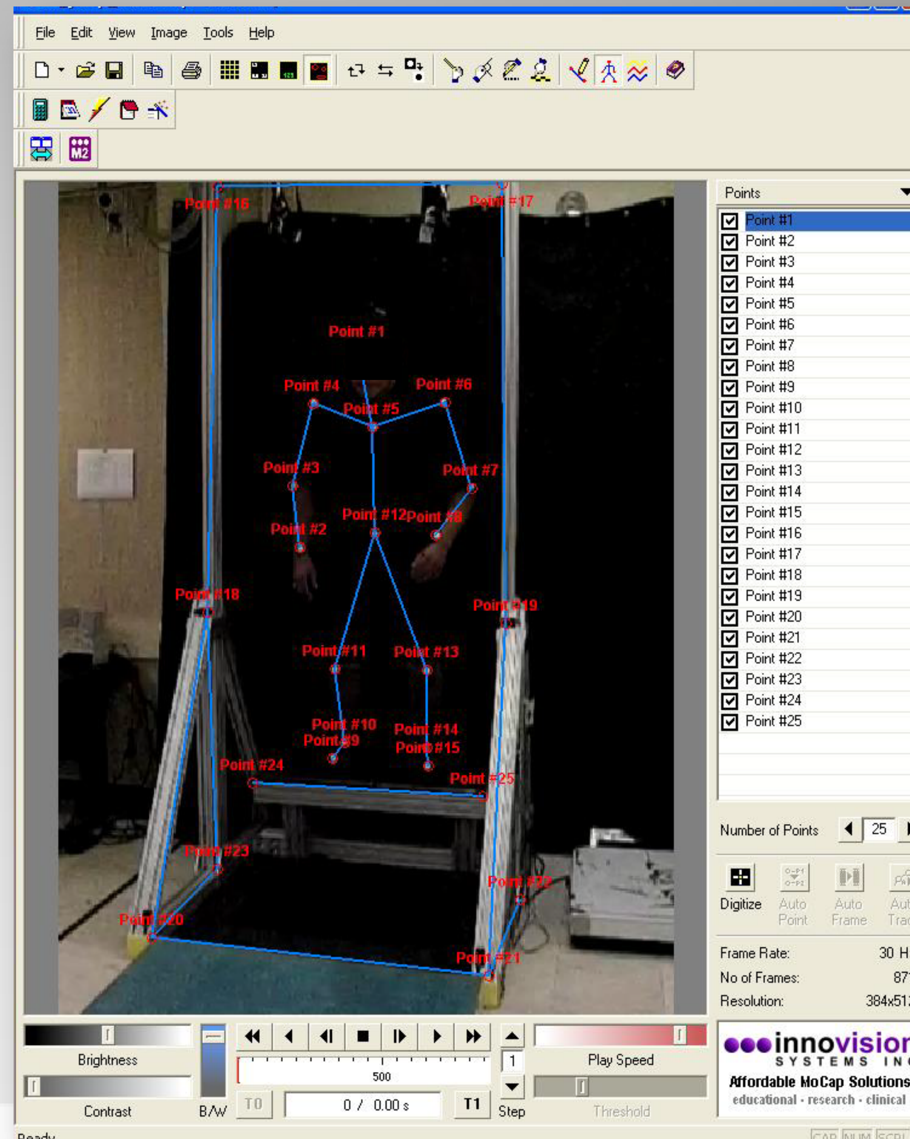


Line Test

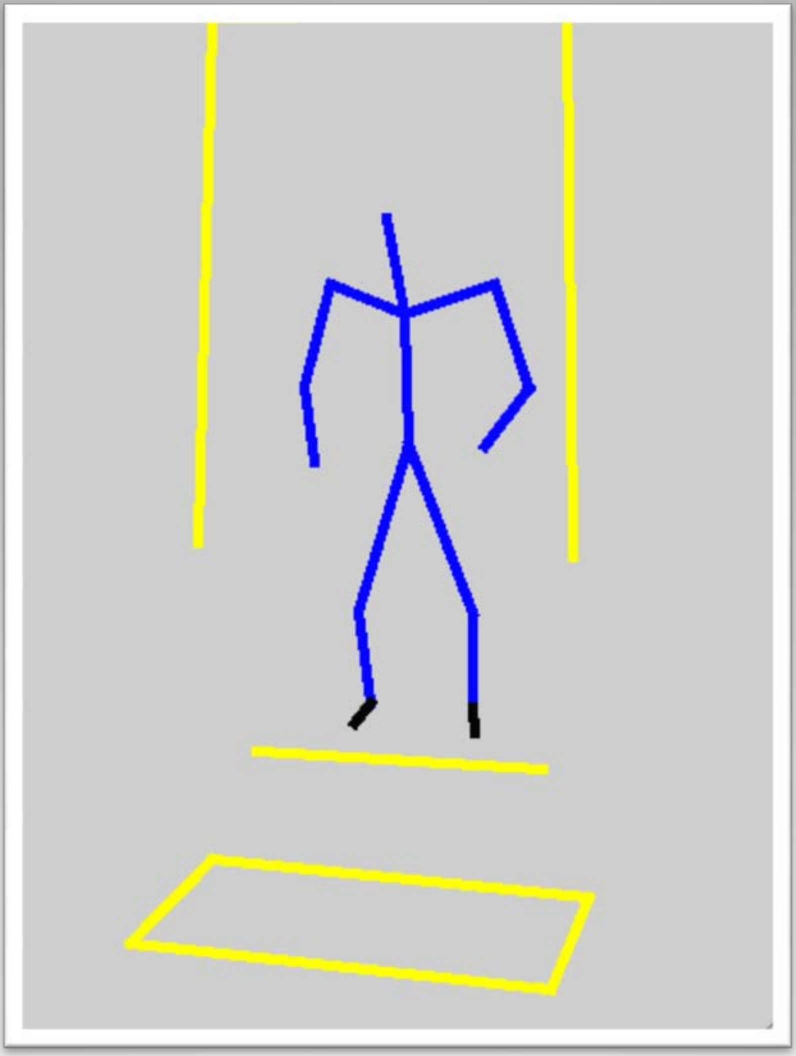


Jump Down Test

- High-contrast markers
- Wall-coverings
- Camera fixed to tripod



Future Testing



Auto-tracked Jump Test

Conclusion

- Video-based motion analysis software was used to digitize Functional Tasks Tests video data, turning the astronauts into stick-figures.
- NASA scientists can now present their research without revealing the identities of the astronauts.
- For future tests, markers will be placed on subjects so the data videos can be auto-tracked using the same software.
- Auto-tracking will allow more accurate movement of the stick-figures.

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- Brandi Butler