Markerless Tracking Identifies Behavioral Changes After Spinal Cord Injury

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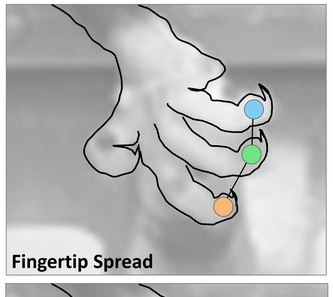
Introduction

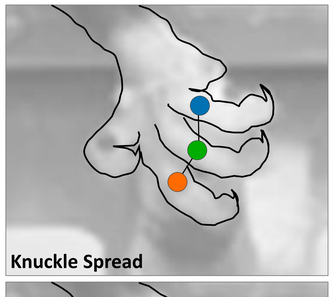
Injuries to the cervical spinal cord impact the ability to complete reach and grab movements including aim/advance, pronation, supination, grasp, and retrieval. Injuries in animal models of spinal cord injury (SCI) targeted at the middle of the cervical region (C6-C7), can isolate the impact of the injury on pronation and supination, without impairing the ability to extend and retract the arm. Recovery from these injuries is limited by the failure of axonal regeneration in mammals. To develop new therapies, scientists often start using in vitro assays. Once candidate therapies emerge they need to be tested in vivo. Behavioral assays can be difficult to interpret because animals, like people, can use compensation (substituting a different kind of movement), to accomplish a given task. The LemBix Lab has previously identified a kinase inhibitor to promote the growth of axons in the central nervous system by an in vitro assay. To test the kinase inhibitor's ability to promote functional recovery and to detect potential compensation in a behavioral setting, machine learning (DeepLabCut^{tm}) can be applied, to accurately track target features pre- and post-injury

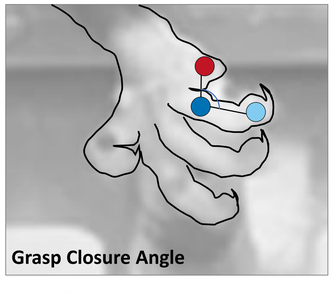
Methods

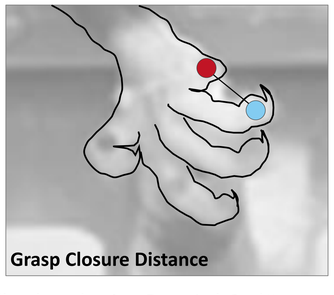
- Nose
- Thumb (Pollex)
- Dorsal Ulnar Edge
- Knuckle Index (D2)
- Knuckle Middle (D3)
- Knuckle Ring (D4)
- Knuckle Pinky (D5)
- Tip Index (D2)
- Tip Middle (D3)
- Tip Ring (D4)
- Tip Pinky (D5)

Once trained on labeled images DeepLabCut^{tm} can identify paw features with individual digit resolution. Spatial relationships between features are then analyzed to identify behavioral changes after SCI.







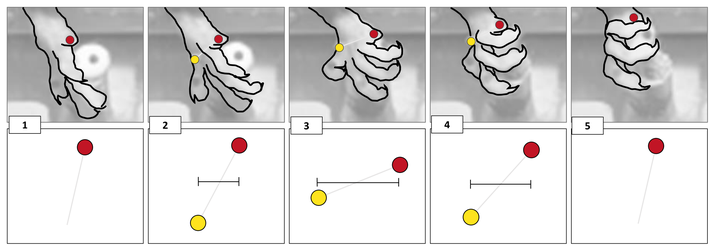


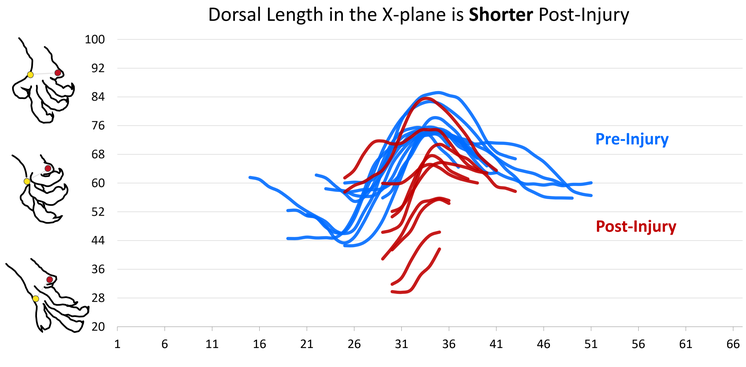
Target markers are automatically placed using DeepLabCut^{tm}

Spatial Tracking of Paw Features Reveals Kinematic Changes after Spinal Cord Injury

Animals Pronate less after Injury

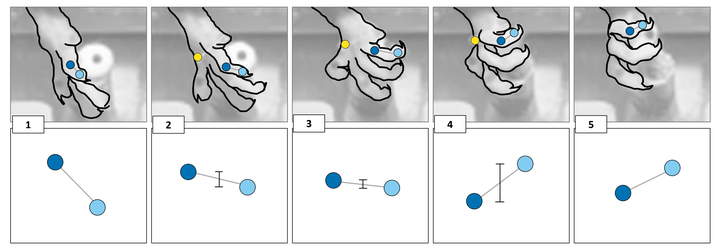
Measuring distances between points across a plane has the capacity of quantitatively describing the level of pronation of an animal before and after injury. By plotting the points of the thumb and dorsal edge over the course of an attempt, the largest change in the X plane can provide an understanding of the angle the paw has pronated.

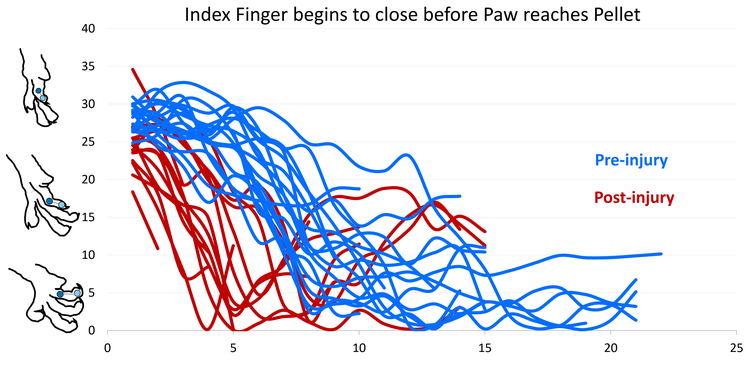




Injured Animals Grasp Prematurely

Utilizing markers on the Index Knuckle and Index Fingertip, the vertical displacement in the paw is quantifiable. This change is then an indicator of grasp in the reach and grab movement. In order to accurately capture the movement, only the frames that included the dorsal edge were analyzed. The dorsal edge is indicated by the yellow marker present in frames 2-4.





Conclusions

DeepLabCut^{tm} is an excellent tool for analyzing behavioral assays. By using machine learning, data that can be acquired that a human observer would have great difficulty detecting and measuring. This approach can also provide a way for researchers to make behavioral observations without having formal training in physical therapy or kinesiology.

This approach can be applied to behavioral studies on animal models of central nervous system injury or disease to assess functional recovery. Of value is the ability to determine if animals are using some behavioral compensation while performing a given task.

References

[1] O'Neill, N., Mah, K. M., Badillo-Martinez, A., Jann, V., Bixby, J. L., & Lemmon, V. P. (2022). Markerless tracking enables distinction between strategic compensation and functional recovery after spinal cord injury. *Experimental neurology*, *354*, 114085. https://doi.org/10.1016/j.expneurol.2022.114085

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