The Design of Lil'Flo, an Affordable Socially Assistive Robot for Telepresence Rehabilitation

Michael J. Sobrepera[1], Michelle J. Johnson, PhD[2]

[1,2]University of Pennsylvania | [1]Department of Mechanical Engineering and Applied Mechanics
[2]Department of Physical Medicine and Rehabilitation | [1,2]Rehabilitation Robotics Lab | [1,2]GRASP Lab

Lil'Flo is a social robot which can assist care teams in classifying patients, tracking progression, and performing therapy for cognitive and upper extremity impairments. The system is being designed to work via assisted telepresence, with autonomy planned. Work is being done to develop computer vision-based diagnostics and define the utility of adding a social robot to tele-rehabilitation interactions.

Need for Robotic System

- Cerebral Palsy (CP) occurs in 2 to 3 per every 1000 live births, making it the most common motor disorder in young children [1]. This is one example of the class of impairments which we are targeting.
- There are a growing number of patients needing therapy without a commensurate increase in clinicians.
- There is a geographic gap between clinicians, located in urban centers, and many patients, located in rural areas.
- There is the potential for robots to make different kinds of connections than those made by clinicians.

Need for Perception System

- Many currently used measures are subjective with poor repeatability.
- Measures which are objective are generally high cost, ex: those relying on human motion capture.
- Availability of highly trained clinicians to perform testing is limited in many low-resource settings.
- There is information lost in the transfer from patient observation to chart records.
- Assessment during therapy could allow better tailoring of interventions to patient progress.

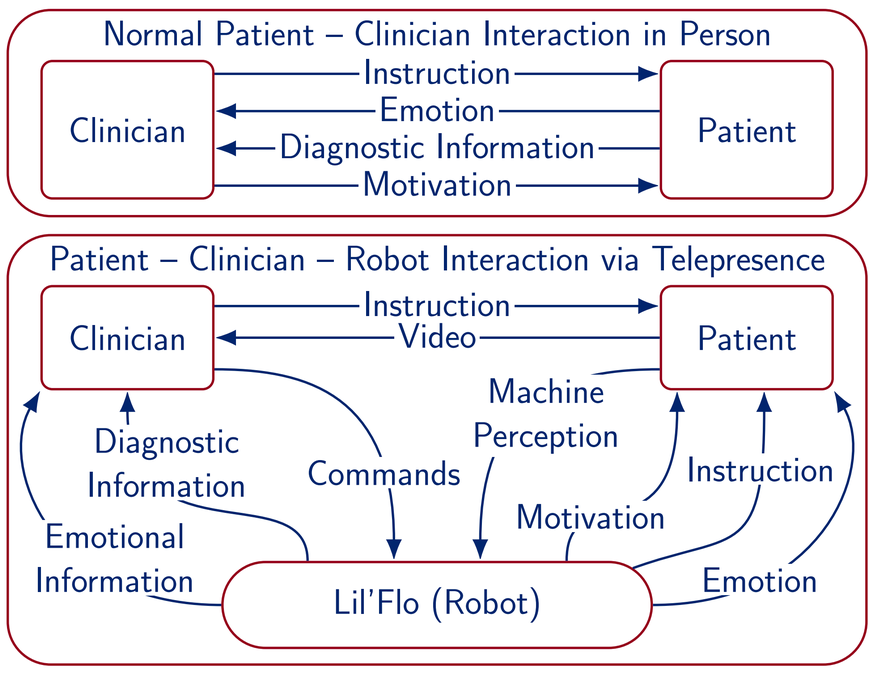
Design Requirements

- Low cost – to maximize impact
- Expressive face – to promote social connectivity
- Easily modifiable hardware – to allow testing of different configurations
- Mobile – to enable remote deployments
- Removable humanoid – to test the effect of the humanoid on interactions
- Various sensors – to facilitate development of the perception system

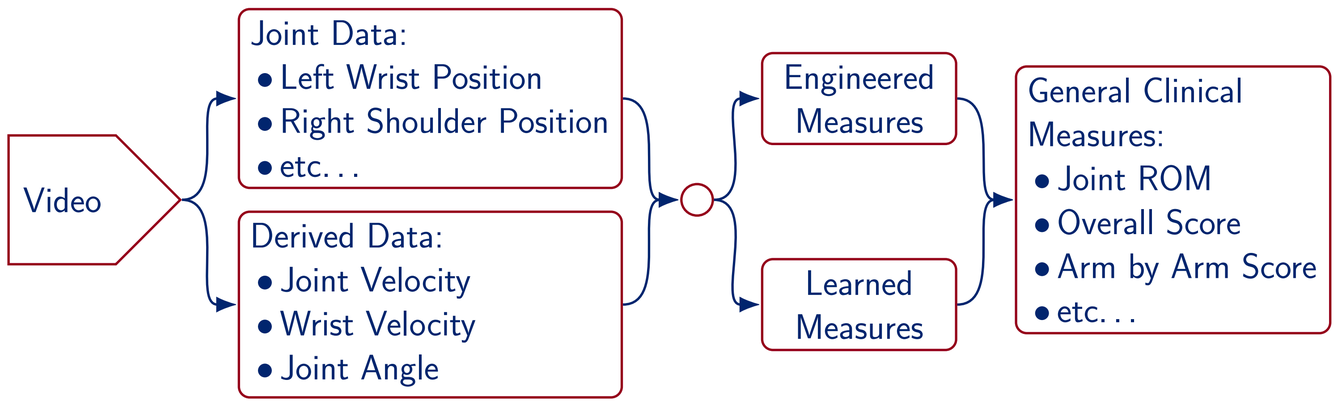
System

- Socially Assistive Robot [2] consisting of a humanoid robot on a mobile base.
- Designed for telepresence now and autonomy in the future.
- Provides a new social agent in rehab interactions.
- Designed to facilitate both diagnostics and therapy.
- Carries on board computer, screen, microphone, and camera.

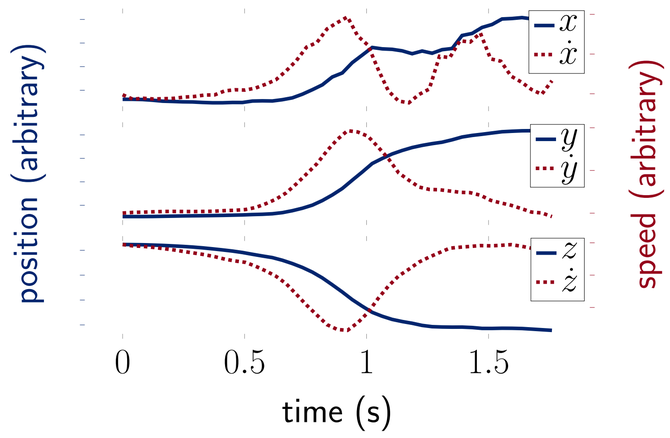
Interaction Model



Perception Pipeline



1. We can leverage tools such as stacked hourglass networks [3] and part affinity fields [4] for 2D pose detection from video.
2. We can use various techniques [5, 6] to extract 3D pose from 2D pose.
3. We can then use measures known from the literature, for example trajectories on point to point motions [7], to measure function.
4. We can also train algorithms to recognize function by gathering data from disabled and healthy subjects.



Data from a video, captured with a low-cost camera, of a healthy person moving their hand to their head.

References

[1] C. Cans, "Surveillance of cerebral palsy in europe: A collaboration of cerebral palsy surveys and registers," *Developmental Medicine and Child Neurology*, 2000.
[2] D. Feil-Seifer and M. Matarić, "Defining socially assistive robotics," *Proceedings of the 2005 IEEE 9th International Conference on Rehabilitation Robotics*, 2005.
[3] A. Newell, K. Yang, and J. Deng, "Stacked hourglass networks for human pose estimation," *Lecture Notes in Computer Science*, 2016.
[4] Z. Cao *et al.*, "Realtime multi-person 2d pose estimation using part affinity fields," *CVPR*, 2017.
[5] X. Zhou *et al.*, "Sparseness meets deepness: 3d human pose estimation from monocular video," *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2016.
[6] F. Bogo *et al.*, "Keep it smpl: Automatic estimation of 3d human pose and shape from a single image," *Lecture Notes in Computer Science*, 2016.
[7] N. Hogan, "An organizing principle for a class of voluntary movements," *Journal of Neuroscience*, 1984.

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