Designing Arms for Lil'Flo, a Socially Assistive Rehabilitation Robot

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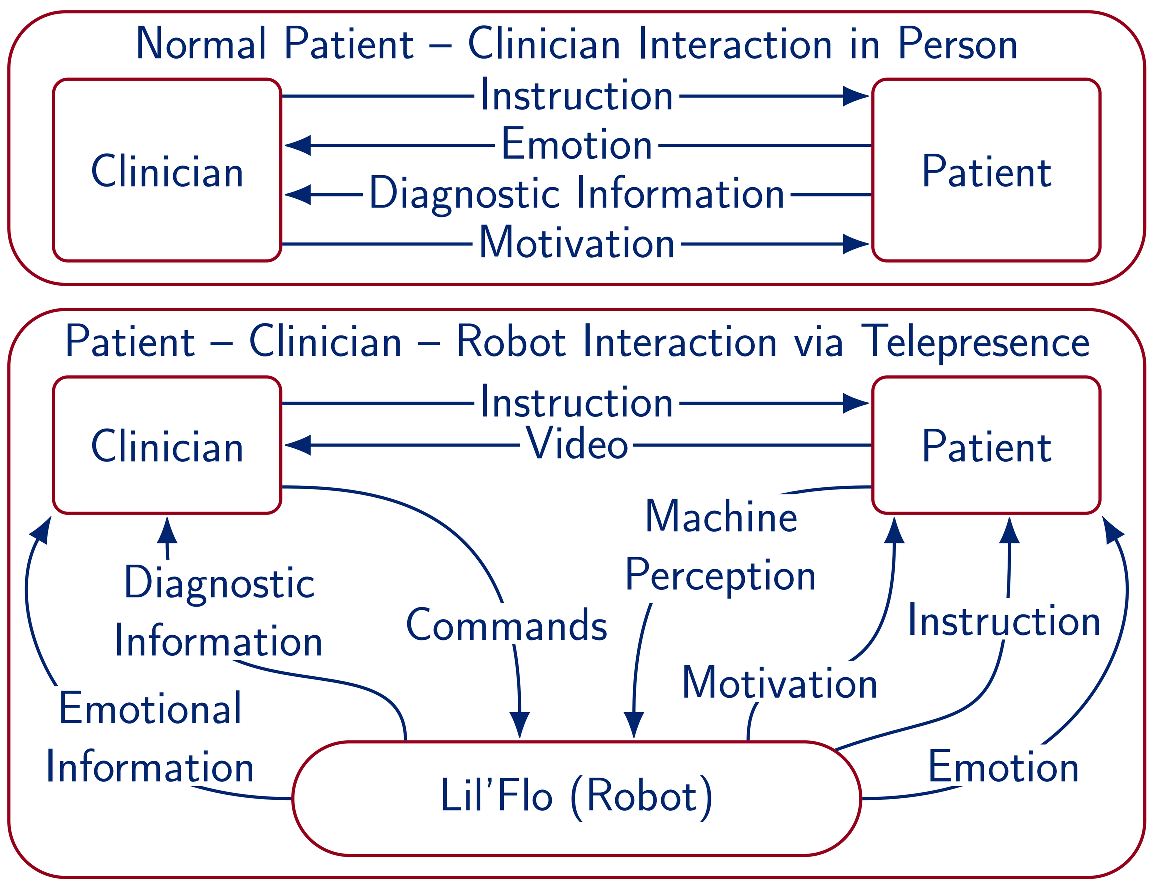
Lil'Flo, a humanoid social robot designed to augment telerehabilitation interactions, has been designed with four degree of freedom arms, using low cost motors which span a sufficient range of motion to be able to demonstrate rehabilitation tasks.

Need

- There is a shortage of rehabilitation workers in rural areas which is expected to get worse. It will affect patients who require rehab, such as those with cerebral palsy, which afflicts 2-3 of every 1000 children born.
- Telerehabilitation could help to alleviate shortages and reduce the burden of travel on patients and their families.
- A social robot with a humanoid form, used to augment telepresence, may be able to build richer telerehabilitation experiences by playing games with patients and demonstrating activities.
- A robot for upper extremity rehab needs arms which can articulate similarly to those of a human to clearly communicate.

Interaction Model

We envision the social humanoid robot acting as a third agent, playing games and demonstrating activities while the clinician guides the interaction with the patient over telepresence:



Motivation for a Custom System

There are a number of commercially available humanoid robots, most notably the Nao. We designed our own system to:

- Allow for easy system modifications, such as changing the colors, form, and sensors.
- Explore the use of a dynamic face for social interactions.
- Demonstrate that low cost hardware can be effective and very expensive systems are not necessary.
- Have hardware which is resistant to damage and easy to repair.
- Have a low weight humanoid which can sit on a telepresence platform without compromising stability.

System

The entire platform consists of a mobile robot base, with a humanoid robot seated on top of it. There are two RGB+D cameras, a screen, and a speaker. The humanoid has two arms with four degrees of freedom each and an expressive face. An Intel NUC is used for all of the onboard compute, running custom software on top of the robot operating system to orchestrate the interactions. The system is designed to support a remote controller who selects games to run with the humanoid and can control the system.

System Cont.

Arm Design Details

Each arm uses four XYZ robotics AI motors which provide digital feedback through an XYZ control board. The arms are made of custom shells which serve as structural exoskeletons and an aesthetic covering. Each arm segment contains two components with one component each for the shoulder and the elbow. The final arms will be white with black elbows and shoulders.

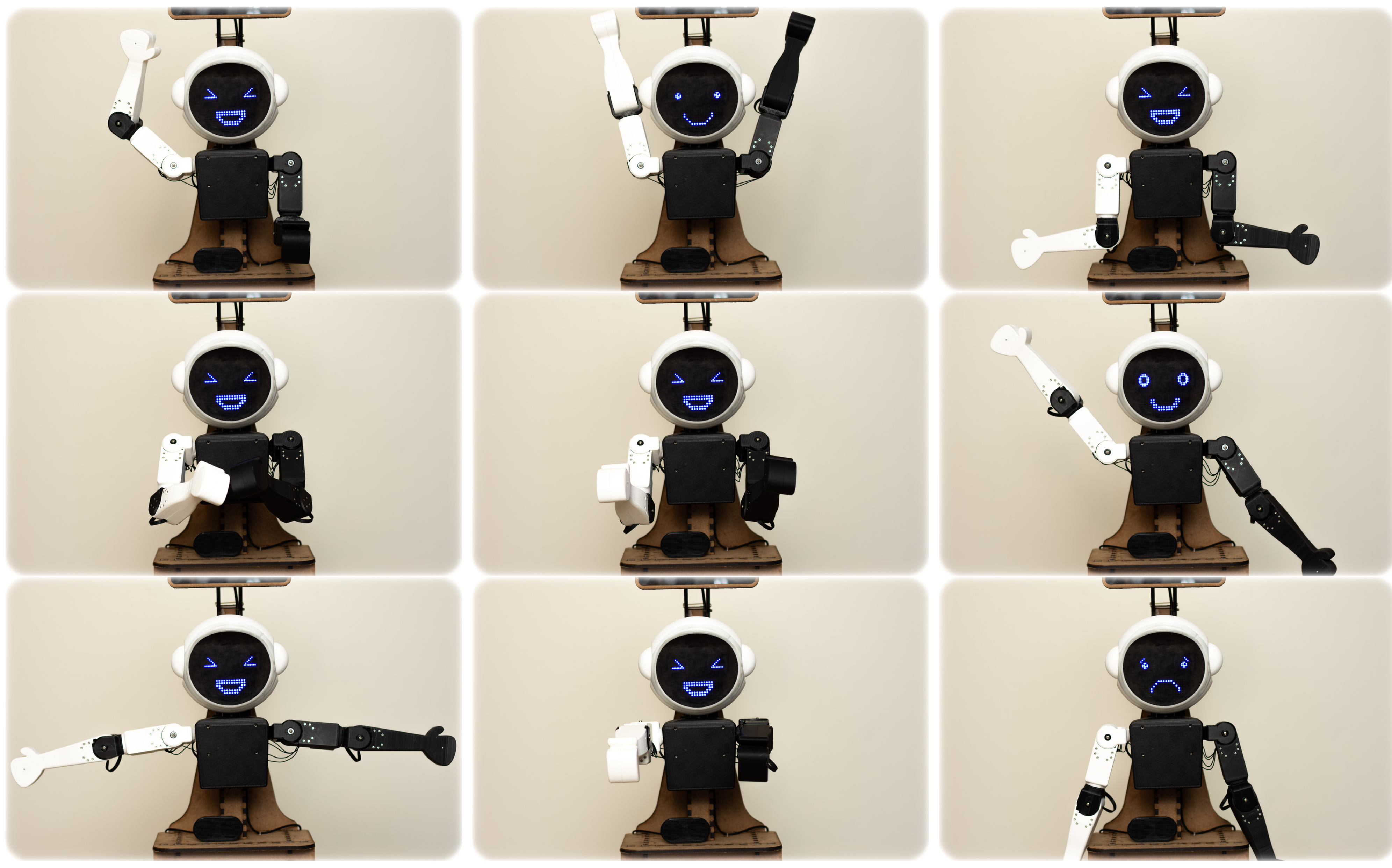
Arm Range of Motion

Joint	Movement 1	Angle (rad)	Movement 2	Angle (rad)
Shoulder	Flexion	3.6	Extension	3.9
Shoulder	Abduction	3.0	Adduction	0.1
Shoulder	Internal Rotation	2.4	External Rotation	3.2
Elbow	Flexion	1.5	Extension	0.7

Results

- The arms provide coverage of the human range of motion, except for shoulder adduction and elbow flexion.
- Elbow supination and pronation are not present, nor are wrist motions.
- The exoskeleton based design allows the arms to be strong, lightweight, modular, and easy to assemble.

A Selection of Arm Poses



Future Work

- Finish and paint the arms and rest of the system.
- Formally test system with target population.
- Develop second generation arms with more controllable motors.
- Re-evaluate design options for the arms, examining form, options for lighting, etc.

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