# Progress Report

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# 1 Specific Research Goals

- Grant Proposal (Oct 14th): Keep working on this.
- VPQEKF (IROS - Mar. 1st): Work on the paper, focus on this in October.
- NBV-Grasping (IROS - Mar. 1st): Work on tasks assigned by Chris, one day a week. Focus on this from November till March.

# 2 To Do

- Grant Proposal: Find three scientific questions to be researched. - Done
- Grant Proposal: Finish the first complete draft of the proposal over the weekend.
- Grant Proposal: Next week, start working on the personal statement, use UTA SOP as the initial draft.
- PVQEKF:
  - Go over code and write matrix equations.
  - I will go over the paper once every morning and expand sections for 30 minutes to an hour.
  - Double-check my data prep implementation. Use KITTI Python module.
  - Test with Hilti dataset.
  - Add L2-norm and L2 loss features.
  - I need to separate the state observation and control input vectors from the
  - Develop object tracking and robust-to-truncation feature.
  - Get ROS environment up and running. I need to install Armadillo (C++) with a certain dependency configuration.
- Real-time pose estimation demo.
- NBV-Grasping:

- Update URDF and Xacro files for UR5e to include a sensor, sensor mount (with offset), and the gripper. – Next
- Add movement constraints for tables and scenes.
- Write two IK functions for gripper and sensor, one for each. It should plug-in with MoveIt configurator.
- Research and implement point-cloud data to training TensorFlow models.
- Learn and implement GraspIt package.

## 3 Progress

The following items are listed in the order of priority:

- Fellowship: Here is a selection of what I have been working on.

  **Background:** Automation and advanced manufacturing in the automotive industry has been researched for decades and yet the wiring harness production and integration remains up to 90% dependant on manual labor [?]. With the emergence of electric vehicles (EV), the wiring harness has become a safety-critical component as it is responsible for power delivery, steering, braking, and sensing.

  To achieve higher levels of safety and quality, more fundamental scientific tools must be developed for adequate handling of wiring harness tasks. The wiring harness problem can be characterized by manipulation, bundling, cavity insertion or handling of deformable linear objects or Kirchhoff's elastic rods as it is known in the literature.

  The automotive wiring harness has a tree-like structure with thousands of wire pieces, components, terminals, etc [?]. Wires with different gauges and lengths are bundled together to form the trunk of the tree and branches deliver power and data connection to the submodules such as exterior cameras, entertainment systems, brakes, etc.

  In recent years, there has been a growing interest in achieving autonomous manufacturing and technologies with robotic manipulation be among the highly researched topics. Although robotic manipulators have found a prominent place on the production line, the automotive wire harnessing task remains up to 90% dependant on manual labor [?].

Due to low and fluctuating volumes, automotive manufacturers tend to implement some form of JIT (just-in-time) production to avoid logistical complications.

**Bridge Background to Problem Statement** Degrees of automation deployed vary among the three stages with the first being most heavily automated and the last being the least automated. The human-machine production rate disparity is clear here
Current elastic rod manipulation approaches could be categorized to two main groups, classical and data-driven. Classical methods such as...

Currently, 70% of wiring harness manufacturing time is spent on the final step and in some areas it is up to 90% manual labor [**?**].

**Hypothesis:** Although there has been considerable effort made towards resolving a multitude of issues regarding handling of deformable linear objects, there are gaps in our fundamental scientific toolbox. These include but not limited to, 1) the lack of necessary engineering tools for rapid reconfiguration and deployment of such systems. In 1996, Kavraki introduced a method, [**?**], for computing *probabilistic roadmaps for path-planning in high-dimensional configuration space* for stationary workspaces. In her method, first a sparse map is computed offline and stored as a graph whose nodes corresponds to collusion-free configurations and whose edges represent collusion-free paths between the nodes. Then, while in operation the robot searches for a path connecting its initial to destination configuration.

In [**?**], Briggs for modeling a Krichhoff's elastic rod by considering a dual-arm approach to form a closed-loop geometric control

In [**?**], Bretl and McCarthy expanded Briggs' approach by reducing high-dimensional space representation of Krichhoff's elastic rods to $^{6}$ [SOURCE??] Moreover, they showed that the set of equilibrium configurations for an elastic rod is a smooth manifold of finite dimension that can be represented by a single global chart.

data set available to researchers, effective tools **Question 1 - Current Limitations -**

Current state-of-the-art technologies are difficult to implement and computation-heavy to reconfigure to even deploy an existing mapping for cable handling in the production environment.

**Question 2 - Knowledge Gaps - Empirical and Simulated Data Set**

**Question 3 - Implementation Difficulties**

Moreover, it is essential to develop easily reconfigurable wire harnessing manufacturing processes and systems. Currently, it involves long computational processes to model and tune or perform transfer learning techniques.

Despite the lack of long research history in this area, recent development have shown promising results. [cite cable harnessing papers]

Relative developments that makes my proposal ideal next step..

Multiple model based and model-free systems have been develop for robotic are manipulation. Current limitations? How can our contribution advance SOTA? Assumption is that the research is not done yet! We don't know the solution and that's okay.

mention the gap
how are we training
Cost functions and rewards

- VPQEKF: No update. I haven't done much with Hilti dataset after downloading it.
- NBV Grasping Project: No updates.
- PyTorch Tutorials: Transfer learning.
- Pose Estimation: On pause.
- SD Team: No update.
- EE Autonobots: No update.

## 4 Intermediate Goals - Fall 2021:

- QEKF: Finish paper.
- Active Learning.

- ARIAC: Once I am up to speed, I will do the ARIAC workshops/tutorials and will talk to Jerry about possible contributions.