This paper ranks at a three out of five to me. The control simplification suggested seems robust, efficient, and sacrifices little in its assumptions. However, the explanation of the proposed method leaves quite a bit to be desired. The idea itself seems to be quite straightforward at least at the high level, but the methodology to present this information is overly convoluted making the main idea difficult to parse. As such, the paper succeeds in its innovations but struggles in presentation as a paper itself. If the writing or proof of concept were better written, then the paper would be more successful as an expression of what is a very strong premise.

The whole contribution of the paper is the FABRIKc methodology for calculating inverse kinematics. This is an iterative methodology for finding viable poses to reach a given end effector orientation and position. It performs better from the previous methodology of the generalized inverse Jacobian in convergence and speed in a significant fashion. It does this by using the assumption of constant curvature to simplify links into two rigid links connected by a joint. With this assumption an entire actuator pose can be quickly calculated since it only has a few parameters namely link lengths and angles. It then iterates on calculating possible poses from the desired pose to the origin and back from the origin to the desired pose. Each iteration it sets one link at its starting location and then calculates the best fit for the intermediate elements. After several iterations it is able to successfully reach the desired pose and then can return the joint parameters for each element.

The success of this paper is tied to its results and effectiveness. Not only is the methodology an order of magnitude faster, but it also shows greater rates of convergence. The Jacobian methodology is prone to high iteration requirements and has the possibility of encountering singular poses that break the entire process. It seems like the FABRIKc process sees accurate movements in lower iterations and without the danger of getting stuck in any local poses. The methodology itself is also incredibly straightforward and seemingly simple to implement. You would not need to calculate the Jacobian which has the potential to get highly complex with a robot that has many degrees of freedom. All that is required is a model of links and their rotations and this methodology can be used, even including rigid links.

The major failure of this paper comes from its organization and problem description. The order that the information was presented in does not help with the understanding, and the desired goal of the task was not clear. By having the rigid joint model before introducing the reader to the method I am left with several pages of material I have no context for. The paper would benefit tremendously from a high-level explanation of what the FABRIKc method is right after the introduction. By having the of the forward and backward reach loop and the nature of an iterative IK method explained briefly before getting into the math will let me have some intuition for the usage of the variables and how they can apply. It is not that the explanation itself isn’t thorough, but I constantly needed to reference the model just to follow what was happening in the later sections. The material is presented in a fine fashion, but the problem as well as the solution are really not clear until more than halfway though the paper.

This paper is a fantastically intuitive method for modeling a very difficult system. It made me wonder about other possible ways to use rigid or simplified geometry to represent the key elements of elastic elements as well as where this joint replacement can be used. It seems like most primarily uniplanar forms of elastic motion could potentially use this. A soft joint (like a robotics knee or elbow) is similar a pin joint where the resistance follows Hooke’s law. Inflatable actuators could be modeled as a series of growing rectangular prisms connected by a similar two joint link. Or a three-dimensional deformable object (like a DEA) could be modeled as a solid where all of the facets are formed by a series of rigid links and rotational joints. While potentially we may lose some information in the abstraction, it seems like many soft robotic elements can be seen as some combination of spring-like forces and this rigid link approximation.