OREGON STATE UNIVERSITY
COLLEGE OF ENGINEERING

CS 461 SENIOR SOFTWARE ENGINEERING PROJECT

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Problem Statement

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ABSTRACT

Optimization has been a focal point in technology since the beginning, but ways to optimize in a general sense have been a difficult problem to solve in computing. But what is the most effective way to go about solving issues with general optimization? As the golden age of technological advancements is present, many more methods have come into play to help solve this problem. Machine learning and AI have become more applicable in a broader sense. With utilizing these advancements in optimizations, what more can we create? Better, more sustainable products? Effective manufacturing techniques? The possibilities are endless as we delve into optimization methods.

I. Problem Definition

General design and product optimization is a major problem in manufacturing. Manually optimizing different designs can be very inaccurate and time consuming, and creating "one-for-one" software to optimize a specific design is too labor intensive and inefficient as it can only be used for one design. This means that one would either have to conduct many hand-tested experiments, or create a new optimization software for every design needed.

As new technology is created, and different methods thought up of, creating a solution for the general-case of design optimization becomes more feasible. A general-case optimization software that could produce accurate results for each design given would be the ideal solution to this problem and would eliminate any extraneous errors that may arise.

Will Allen of HP has proposed a challenge to create a statistically driven optimization software that performs calculations on sets of parameters which would result in the optimal solution for a given design. This specific problem could be utilized in many different manufacturing settings. The focus of the problem resides in Computer-Aided Designs (CADs) that are 3D printed. This optimization could theoretically produce accurate results for very complex designs such as: 3D circuitry, robotics, and mapping systems. The potential applications of this technology could serve as a stepping stone towards bigger and better optimization software with a broader reach.

II. Impact

General optimization will have a broad reach in many different fields from product manufacturing and civil, mechanical, electrical, etc., engineering; to business operations and practices. Streamlining the design process, and improving on existing designs could yield incredible feats in efficiency, reliability, and longevity in things not limited to: the design, construction, and maintenance of the physical and naturally built environment; general products; technology; etc.

While our specific project is on a somewhat small scale, we believe that the technologies it uses could be adapted to be used in several other fields, any place where a series of items needs to be produced and tested with variable parameters. Ultimately, the results of this project will likely be at HP Labs' discretion to choose how they, and potentially future Oregon State Capstone students would like to expand upon it.

III. Solution

Creating a "one-for-all" optimization software that utilizes different mathematical concepts is the overarching solution to this problem. Utilizing statistical design of experiments to create algorithms that produce different functions and calculate the optimal creation of said design is the foundation of effective solutions. The algorithms must intake predetermined parameters from multiple variations of one design, make calculations on the parameters to "rank" the variable designs, trimming the designs, and creating a solution that optimizes the design for specific needs. Creating multiple computer-aided designs with different specs is the first step to the experimental phase. Having working "test subjects" and creating the list of parameters to calculate on will be the foundation of software development, since the software cannot be run without the data set, and performance metrics. Utilizing tools like SolidWorks to design the mechanisms, and having access to a 3D printer are necessary requirements.

Once the designs are printed, the algorithm development is the next priority. Planning the skeleton of the software and how it intakes and calculates data is important for the beginning phases. Once an initial design is agreed upon, the next step is implementing the data input and output and creating the algorithms for the statistical optimization of the designs. To find the statistical optimization of the designs, we could use regression modeling, a linear algebra approach, or a machine learning approach. After we get the results of the test data, we will analyze which approach will be the best fit. Regression modeling is efficient if the variables and our target are in the linear relationship, a linear algebra approach is efficient if we can find any relation from the data, and a machine learning approach is efficient if we cannot find any relationship between the variables and our target.

Finally, testing the different designs and making corrections is the last step in software development. Having experiments with designs that already have an optimal would be ideal, but not necessary in software testing. One can also do the experiments with simulations having the logic complete and theoretically solving those problems. This ties in with how to implement evaluation of the performance and accuracy of the software.

IV. Performance Metrics

In order to evaluate the software we must have multiple known solutions to different experiments. Since the algorithms are supposed to be able to run in a general sense, it is important to have a variation of parameters, number of parameters, and designs when evaluating. Running the software on data gathered for the parameters of the varied designs should then produce the most optimum configuration of specifications for the design.

There are some simple benchmarks we can check to see if the program could be considered successful; we can judge its performance metrics based on whether or not it meets those benchmarks. If the program works then we will know we have "successfully" completed it. However, a program that is slower or less efficient than humans is of no use to anyone. We could potentially compare the accuracy (how often the program solves the problem correctly) and the speed (how long it takes for the program to complete) to a human attempting to do the same thing, and rate its overall effectiveness (combined speed and accuracy). Depending on the client's values, they may consider it a success if the software is cheaper (fiscally or otherwise) than a human despite it being slower. The current goal is to be as efficient as a human doing the same task.

There are also performance metrics listed on the web portal where the project was first listed: By the end of fall term, we should have created a design and be able to instantiate 64 instances of it in a single run of an additive manufacturing device. By the end of next term, we should have adjusted the design to be a force threshold sensitive latch (will lock into a new state if enough force/pressure is applied to it), and use statistical methods to automatically adjust the parameters of the design in order to find a model that is better. We must also produce and measure the performance of the optimized design. By the end of spring term, we will hopefully have optimized the design to 4 "force threshold latches all with distinct latching thresholds". These measurements all seem within the realm of possibility especially with a team of three.

V. Conclusion

Manually optimizing different designs is too time-consuming and inaccurate, and creating a "one-for-one" software method is inefficient in its use of resources. Having software that can produce optimal solutions to different designs would be the most valuable process for this problem. Utilizing advancements in technology, the solution to this problem becomes feasible. Statistical mathematics, AI, and machine learning become the core of the software allowing for optimization software solutions for general designs with specific parameters. This technology can be utilized in manufacturing for optimizing products, technological advancements, research, which could be the catalyst for improved optimization methods.