SMATS: Sketch-based Modeling and Analysis of Truss Systems

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Objectives:

- Providing a domain-specific sketch method for modeling and analysis of forms and structures concurrently.
- Particularly addressing architects, aiming to provide a natural environment for them to present and appraise structural configurations of different truss systems by means of sketching.
- Optimizing the conceptual design of trusses by bridging architectural vision in creating forms, and engineering analysis. It helps architects gain better understanding of the effect of variation in form on structural behavior of trusses.

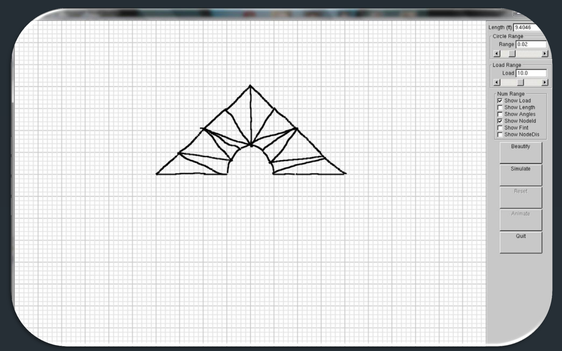

Figure 1. Any desired form can be drawn on the sketch pad. Appropriate supports and loads can be assigned to the sketched model by drawing symbolic gestures.

Motivation:

Architectural Design
Architects live through the world of sketches. Despite the advances in computer aided design (CAD), architects initiate a conceptual design through sketches on paper or a sketchbook. It then goes under careful CAD modeling process to be presented as a structural model for engineering analysis.

Engineering Design
Design in terms of engineering is an iterative process. To create an optimal design, the engineer must develop different alternative solutions through analysis, evaluate each one, and then select the alternative that best satisfies the design requirements. One of the principal criterions in engineering design is to maintain the limits of forces and deformations of the structure.

Throughout the design process,
the initial concept is usually altered several times.
This may affect the architect's intention in terms of the original design.

However:
if the architects are provided with an understanding of the structural behavior of their conceptual design, they could alter the design perceptively by comparing alternatives instantly during the preliminary design phase. This would facilitate the design process, while improving the architect/engineer interactions. This is achieved using current state-of-the-art sketch-based UIs provided by computer science technologies which can handle the geometry very well, as well as engineering analysis and possibility of manipulation simultaneously within the same environment

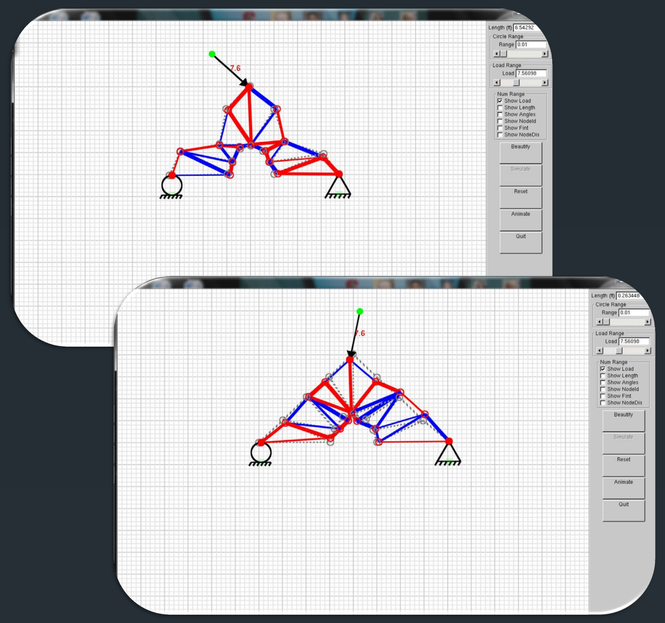

Figure 3. Once the sketch goes under engineering analysis: The user can explore the internal forces generated in the members through color and thickness code, as well as the exact values of these forces. The user can also observe the animation of the structural deformation under the applied load.

How SMATS works:

The UI for SMATS provides architects an interactive environment as simple as their sketchbook:

User Interface:

- The user can create the outline of his/her design using a stylus. And assign load and support conditions to the nodes.
- $1 Unistroke Recognizer is used as a gesture recognizer in order to determine required data for further analysis.
- The structural behavior of the sketched configuration is modeled in real-time. The results are brought back to the same user interface for visualization.

Interaction:

- SMATS is designed to allow the user manipulate the sketched configuration of a truss while receiving instant feedback on its structural behavior. Once the sketched truss is recognized by the program, an enhanced version of the model with the standard symbols will replace the sketch through beautification. This takes the user to the interaction mode where he/she will have the option to either visualize the behavior of the sketched design under the assigned loads, or manipulate the design to a desired geometry, load, and support condition.
- The user can create or remove nodes and members, or supports using certain gestures. Also, the user can move the position of nodes by dragging the node locators. This gives the ability to compare different configurations and optimize the design both aesthetically and structurally.

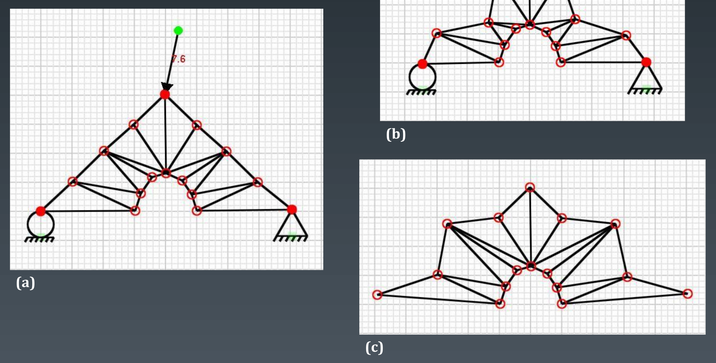

Figure 2. (a) Shows the beautified truss after sketching where the user has added supports and load. (b) & (c) The user can manipulate the design to any new configuration by dragging the node locator. The user can also add/remove members, loads, and supports all using the stylus.

Analysis:

- The behavioral feedback visualization is in the form of color/thickness codes for internal forces members, and animation of structural deflections under the applied loads.
- Software training as it is required for the traditional menu-driven tools is not needed in here. SMATS is a self-training UI where an architect can gain engineering perspective on the structural behavior of forms through using the program iteratively.

Conclusions:

The present work is part of an ongoing collaborative research effort in the area of architectural, structural engineering and computer science to develop sketch-based tools for non-engineers, to facilitate and optimize the design process.

- This allows architectural freedom to create forms, and better comprehend their relationship to structural behavior, without the need to learn or concentrate on the software-specific tools. The main application of the presented software is to facilitate the what-if scenarios using a visual representation of the structural analysis conducted by SMATS.
- The interactive environment of the UI allows the user to manipulate the design and observe the outcome of changes on the truss structural behavior. Iterative usage of the method will give architects engineering perspective about the class of structures used here.