The EmotiveModeler: An Emotive Form Design CAD Tool

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Abstract
Whether or not we are experts in the design language of objects, we have an unconscious understanding of the emotional character of their forms. The EmotiveModeler integrates knowledge about our emotive perception of shapes into a CAD tool that uses descriptive adjectives as an input to aid designers in creating objects that can communicate emotive character. Through inputting words into the EmotiveModeler UI in the Rhinoceros 3D modeling software, both expert and novice designers can manipulate the design of a bottle to express emotive character through its form.

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Design; emotion; semantically-driven CAD tool

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D.2.2 Design Tools and Techniques; J.6 Computer-aided engineering (computer aided design).

Designing Emotive Meaning in Objects
The form of objects is one of the first aspects of a design we perceive and is often one of the first features expressed by designers [11]. Whether or not we are experts in the design language of natural or man-made objects, we can readily perceive information in forms such as Disney's iconic twisting sack of flour [21]

Background in Shape-Emotion Research

Experiments carried out by Poffenberger [16], Collier [3] and Isbister [6], in which participants associated various shapes to different emotions, e.g. smooth forms show more positive emotions, contributed to a qualitative understanding of what design elements are more often associated with which of the eight primary emotions. These qualitative design elements were then broken down into more quantitative design variables that make up a form, e.g. smoothness, leaning direction, distribution of volume, aspect ratio, etc.

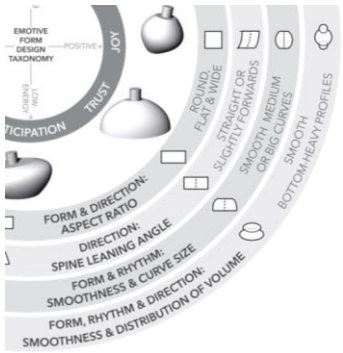

Figure 2. Segment of emotive form design taxonomy

(Figure 1), and often associate an emotive 'character' to them using the language that we can all understand; words [8]. Product designers are sensitive to the symbolic qualities of man-made forms that affect our perception – the product semantics [10]. They draw upon their knowledge of metaphors, anthropomorphism and spatial design rules early in the creation process to transform the abstract meanings of emotional experiences into the geometric units that construct the 'product language' of solid objects [1, 4, 5].

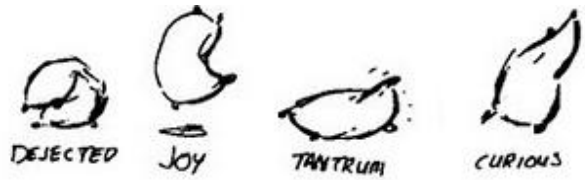

Figure 1: An animated flour sack conveying emotions taken from "The Illusion of Life: Disney Animation" [21]

Designers often generate the final three-dimensional models of these objects by using complex Computer-Aided Design (CAD) tools such as SolidWorks, AutoCAD and Rhinoceros, whose operational affordances require designers to describe the forms in very concrete inputs such as dimensions and curvature rather than in our more abstract and natural verbal lexicon [4, 20]. Advancements in more accessible CAD tools that allow novice designers to simply 'drag and drop' forms into a 3D model [7], or use evolutionary modeling [19], computer vision [2] and machine learning [9] to create frameworks that map descriptive words onto a modular set of existing 3D designs have made this process slightly easier. However, the early part of the design process - where a designer can use semantic connections to understand what *sort* of forms will best stimulate our emotional reactions and convey the meaning they want - is still very hard for beginners. What if this initial stage of the creation process - where ideas are broken down into analogies or words and transformed into forms – could be understood and systematized, so that novice designers too could convert their concepts into physical forms? Could a CAD tool that used descriptive adjectives as an input aid designers in creating objects that can communicate emotive character?

The EmotiveModeler is a semantically-driven CAD tool that aims to make this early design phase more intuitive, by using expressive words as an input to generate designs whose forms convey the associated emotive character. By creating a quantitative emotive form design taxonomy that builds on existing research into our natural emotional reactions to shapes, the EmotiveModeler connects this design language to our familiar verbal language to help both novice and expert designers create emotively communicative forms.

The EmotiveModeler CAD Tool

Research to understand our perception of different sensory stimuli has shown that simple attributes such as shapes can reliably convey certain emotional responses unconnected from contextual, cultural or personal idiosyncrasies [3]. The EmotiveModeler builds on existing emotion theories (particularly Plutchik's model of primary emotions [15] and Russell's valence-arousal circumplex model [18]) as well as shape-perception theory (see sidebar Background in Shape-Emotion Research) to create quantitative dictionaries that map words and shapes to an underlying set of primary emotions, and through these create complex 3D forms that can convey multi-emotion words.

A Brief Intro to Rhinoceros

A simple way to build a 3D model in the Rhinoceros (Rhino) 3D modeling software [17] (the CAD tool used to develop the EmotiveModeler) is by creating a lofted surface from several profile curves (Figure 3). Curves contain varying numbers of control points in a certain distribution, with straight or curved lines joining the control points (defined by a line curvature degree). By distributing the planes of these curves away from each other, a smooth or faceted surface can be lofted along the curves (defined by a loft curvature degree).

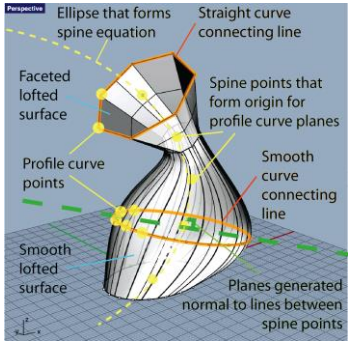

Figure 3. Design attributes in constructing a form in Rhino

The dictionary that maps words to emotions uses Mohammad's NRC Emotion Lexicon to associate over 14000 words to Plutchik's eight primary emotions – joy, anger, fear, sadness, trust, anticipation, surprise, disgust [14]. Using the same primary emotions, a quantitative emotive form design taxonomy (Figure 2) was created that transforms the qualitative descriptions of specific shapes into quantitative design variables that can be manipulated by functions in the Rhinoceros 3d modeling software, e.g. altering the loft curvature degree can make a surface angular or smooth (see sidebar A Brief Intro to Rhinoceros). A third dictionary weights these design variables so that when forms are created from multi-emotion words, e.g. 'alarm' = fear + surprise, the design features important in conveying certain emotive qualities are not averaged out.

These dictionaries form the basis of the EmotiveModeler CAD tool (developed with the Rhino software, Python plugin and other libraries [13, 17]) that manipulates the forms of 3D models so that their shapes reflect the emotive character of words entered by the user. Users interact with the EmotiveModeler through an interface (UI) that controls the underlying Python program and through this the Rhino 3D modeling functions (see sidebar EmotiveModeler UI). A new object to design is first selected – a bottle in this initial prototype – and a neutral form is generated in the 3D modeling space. Users – both novice and expert designers - can then enter words (one or many) into the UI, transforming the shape of the object so that it reflects the emotions associated to the input word. A feedback loop is integrated into the EmotiveModeler to allow users to adjust the amount of primary emotions related to specific words suggested by the tool to match their individual perceptions, enabling a more 'creative conversation' between the irreplaceable human creativity of the designer and their tool [12]. Once the user is happy with the design they have created, they are able to render an animation of it and save it as a Rhino 3D model for further manipulation if they desire.

Discussion

Testing our hypothesis that the EmotiveModeler could aid designers in creating objects that communicate emotive character, user studies that evaluated participants' perception of designs created by the tool highlighted a few modifications to the underlying emotive form design taxonomy required to improve the correlation with the designers expectations. In other studies that tested the EmotiveModeler CAD tool itself, despite participants' frustration at the lack of detailed manipulation, the intuitive connection between words and basic forms was considered an interesting and useful aspect of the tool. As hoped, this tool did indeed make the early stage of transforming abstract ideas into concrete geometric forms that communicated emotive character easier for both novices and experts.

This work is a first step into understanding how we may create design tools that take advantage of our intuitive perception of the emotive meaning in objects. In future iterations of the EmotiveModeler, larger online studies could highlight more modifications to the emotive form design taxonomy and improve the efficacy of the tool. Understanding more about the context of the object could also able integration of directly referential associations into the designs to further enhance the meaning conveyed, e.g. the colour or shape of a chili could enhance the design of a 'fiery' hot sauce bottle. Developing the EmotiveModeler to input images or even data and output a wide range of

EmotiveModeler UI

Users can input one or many words into the UI (Figure 4) and generate designs based on the emotional character of those words. They can also modify the emotions related to those words, and hence the form of the design, using the primary emotion sliders.

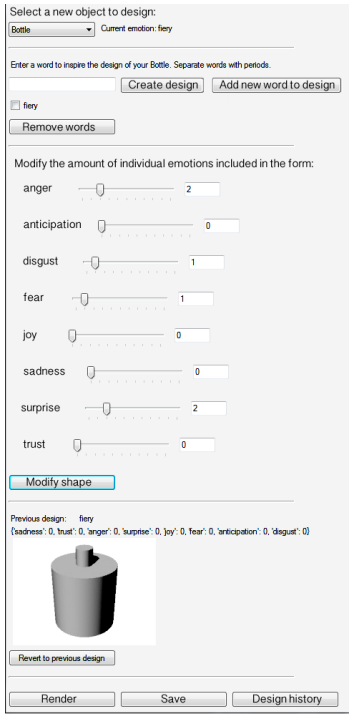

Figure 4. EmotiveModeler UI

design attributes could move towards creating a total 'synesthetic-communication' design tool, giving both novice and expert designers a more intuitive way to communicate through the medium of design.

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