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Efficiency parameters estimation in gemstones cut design using artificial neural networks

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Abstract

This paper deals with the problem of estimating cut results for faceted gemstones. The proposed approach applies artificial neural networks for a faceted gemstones analysis tool that could be further developed for incorporation in a computer-aided-design (CAD) context. Basic concepts concerning gemstone processing are introduced and the design of computational tools using neural networks is discussed. The model presented proposes two criteria to assess the efficiency of lapidary designs for rock crystal quartz: brilliance and yield. Closing the article, 62 different lapidary models were used to train and test the neural network tool.

Keywords: Faceted gemstones; Lapidary design; Design efficiency; Artificial neural networks

1. Introduction

The minerals qualified as gemstones are remarkable and attractive in consequence of special characteristics like color, brilliance, transparency, hardness, durability and rarity. Its beauty, essentially associated with their optical features, has made these precious stones very attractive for diverse applications related to adornment objects and its rarity has assigned high exchange value to them. Man's fascination with gemstones dates from prehistoric times and since the beginning of civilization, examples of efforts to improve the optical properties of some gemstones are found, aiming at enhancing its beauty and, consequently, its exchange value [1].

One of the most important ways to aggregate value to the gemstones is lapidary, the general denomination of the cutting and polishing processes applied to solid materials. In the field related to this work, lapidary techniques are still being developed in terms of producing even more sophisticated models, seeking to control color saturation, to maximize the return of incident light from the observer perspective, to obtain interesting distortion effects of light rays inside the gem, to reduce wastage in the raw material cutting, or simply to allow the setting of the gemstone on the jewel assembly [2,3].

This article presents a study of the application of artificial neural networks (ANN) on efficiency in parameters estimation and evaluation of lapidary design results considering the technique of faceting. Application of ANN-based tools on materials science and engineering is becoming an interesting issue for design, characterization and evaluation problems. For instance, some useful ANN applications on materials science can be found in [5,4,6]. The results or efficiency of such lapidary designs can be measured in terms of optical performance and weight retention. The optical performance of gemstones can be judged primarily for its brilliance, defined as the portion of incident light that returns to an observer after traveling through different paths inside

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the gem. The weight retention, here called yield, is the weight ratio between the raw material and the final faceted gem obtained after the cutting and polishing tasks [7–9]. Computational tools based on artificial neural networks have been applied to different kinds of problems where it is necessary to extract knowledge from strongly nonlinear and complex systems, being the case of the relationship between the geometry of three-dimensional faceted gem and its brilliance and yield results.

This study's subject relevance can be observed in some recent related works concerning these two main gems properties. For instance, an interesting hybrid artificial intelligence approach for the yield improvement is described in [10]. A computational tool for quality grading, based on rule-based knowledge representation, fuzzy logic and genetic algorithms, provides better understanding of lapidary possibilities and therefore can contribute to wastage reduction when real faceting actually takes place. Another innovative work presents a detailed study of optical effects inside a polyhedral faceted gem, modeling the complex behavior of light in such materials, and proposes an efficient computer graphics algorithm for rendering faceted gemstones and obtaining a photo-realistic graphic representation of optical effects such as color and brightness [11].

The international jewellery industry is the final destination of most part of faceted gems, turning about 14 billion dollars per year on the international trade (estimative of

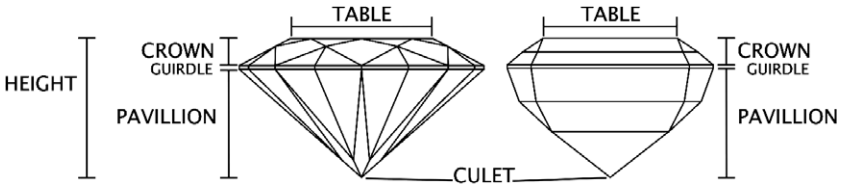

Fig. 1. Nomenclature of a faceted gemstone.

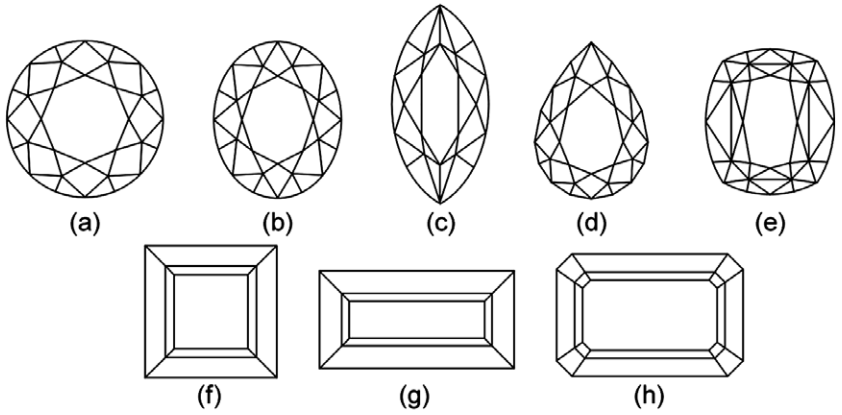

Fig. 2. Top view of typical gemstones: (a) round, (b) oval, (c) navette or marquise, (d) pear, (e) cushion, (f) square, (g) rectangular or baguette, (h) octagonal or emerald cut.

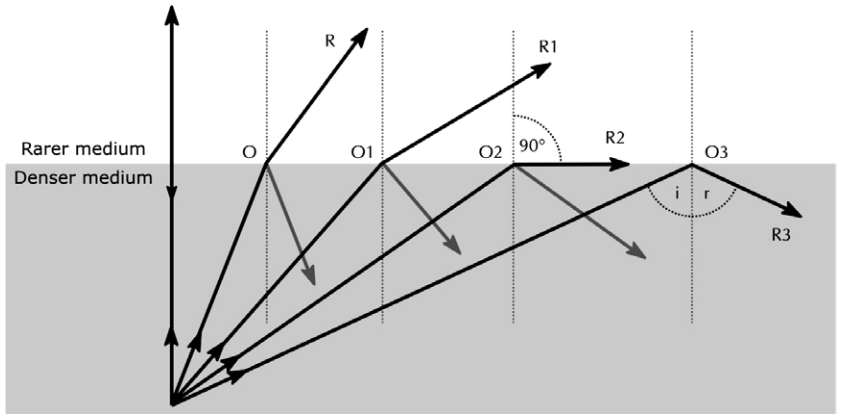

Fig. 3. Light refraction and total internal reflection phenomena on two different materials interface, with different refraction indexes.