The feasibility of automated gemstones identification using optical properties and Artificial Intelligence (AI)

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Abstract

A method has been developed to automatically characterize the type of gemstones by optical properties of gemstones, digital image analysis and Artificial intelligence (AI). The method relies on optical properties of gemstones analysis as well as digital image acquisition and image processing. One hundred series of digital images were taken from 50 samples from different area of Iran and then transmitted to a dataset. Basic optical properties of gemstones (colour, transparency, lustre, fractures, cleavages, inclusions, pleochroism, phenomenon and birefringence) are selected. Crystals of demantoid with green to yellowish-green colour, crystal clusters and single crystals as large as 10–20 mm (most range from 2 to 10 mm in diameter) have been selected in the study area [1].

The accuracy of gemstone identification using the method was %92, and %95 for agate and demantoid respectively. The method is applicable to other gemstones and it is possible to recognize the gemstone samples with the accuracy of more than 98%.

Keywords: gemstone; Artificial intelligence (AI), demantoid,

1. INTRODUCTION

The identity of a gemstone is determined using a combination of visual observation and spectrochemical analysis [2]. Identification and classification are often accompanied by the use of conventional gemological tools, which include refractometers, polariscopes, spectroscopes, dichroscopes, and ultraviolet light, to probe the optical properties of gemstones as well as advanced instruments which include infrared spectrometers, Raman and luminescence spectrometers, X-ray Diffraction (XRD), *Scanning Electron Microscope* (SEM), *Transmission Electron Microscope* (TEM), ultraviolet–visible spectrometers, cathodoluminescence, energy-dispersive X-ray fluorescence spectrometers, laser ablation-inductively coupled plasma-mass spectrometers, and

fluorescence spectrometers, X-ray absorption near-edge structure (XANES) and Extended X-ray Absorption Fine Structure (EXAFS). The identification is still difficult and time consuming, and not all laboratories have access to these sophisticated instruments; thus, the identification through automatic techniques based solely on images is attractive [3]. The optimal combination was provided by a Random Forest algorithm with the RGB eight-bin colour histogram and local binary pattern features, with an accuracy of 69.4% [3]. For higher accuracy, the artificial intelligence (AI) technology uses deep learning models trained on multiple data sets to help gem experts determine gemstones' identity, authenticity, and country of origin with improved consistency [4]. The multiple data set includes analysis results from optical and chemical spectrometers, as well as information identifying the characteristics of heated or clarity-enhanced stones [4].

In recent years, rapid advancements in technology, particularly artificial intelligence (AI), have been transforming various sectors, and the jewellery industry is no exception. Leveraging AI technologies is revolutionizing how businesses operate within this traditional industry, driving innovation, efficiency, and personalized customer experiences [5].

The aim of this research was to evaluate the possibility of developing an Artificial intelligence algorithm which allows the automatic gem identification by optical properties. microscopic images of rocks. It is intended to follow and simulate the professional judgment procedure adopted by a mineralogy expert in determining an unknown gemstone through visual examination of sample.

2) Materials and Methods

A total of 50 samples of gemstones were obtained from different localities (Kerman, Neyshabour and Torbat Hydarieh) and studied in this research. The samples were grouped into 5 categories, the following 28 varieties were selected and analysed: Demantoid, Agate, Emerald, Turquoise, Almandine, Amethyst, Andradite, Chalcedony, Chrysocolla, Citrine, Diamond, Fluorite, Jasper, Lapis Lazuli, Malachite, Onyx Black, Peridot, Pyrite, Pyrope, Quartz Lemon, Quartz Rutilated, Quartz Smoky, Ruby, Sapphire Blue, Serpentine, Topaz, Tourmaline and Zircon.

In 2001, demantoid garnet from Iran was discovered in Kerman province in the southeast of the country [6]. Demantoids of different parts of Kerman area (Baghin, Kouh Gabbri, Bagh Borj, Soghan, Gol Gohar, Kouh Tanbor, Khajoo), show wide ranges of optical properties and chemical compositions. In this study, we carried out a Comprehensive study of garnet mineralogy as well as major and optical properties of garnet from different stages of mineral deposit by trace elements and REE substitution mechanism conditions and change in garnet composition at different stages

3) Results and discussion

A method has been developed to automatically characterize the type of mineral phases by means of digital image analysis using optical properties of crystals [7]. But, the proposed automatic Gem Artificial intelligence (GAI) scheme is validated for its ability to successfully identify unknown gemstones through appropriate samples. The following typical unknown gemstones are selected for the validation process: 1) Demantoid Garnet which belongs to the isotropic mineral class. 2) Agate which belongs to the anisotropic non-pleochroic mineral class with low birefringence. 3) Turquoise as a member of the anisotropic biaxial mineral, but has a medium birefringence.

The results showed that the proposed GAI scheme is significantly successful in determining the unknown gemstone. Based on mineralogical studies, garnets from the Kouh Gabbri can be divided into 4 different types. Type 1, pure andradite (Adr>59) associated with sulphide stage. Type 2, Al-rich andradite, formed at the early stage of amphibole- epidote- hematite stage. Type 3, a solid solution between grossular and andradite. Type 4, grossular, formed at Ca-silicate stage. The XRD experimental data, showed that the main component of the garnet is andradite. Most of the samples studied had a green or deep green homogenous colour. Due to changing physicochemical conditions, garnets in the study area display variations in inclusion, texture and composition.

4) Conclusion

The results obtained in the validation stage of the proposed gem identification scheme prove its efficiency and success in the diagnosis of unknown gemstone. This shows that colour, transparency, lustre, fractures, cleavages, inclusions, pleochroism, phenomenon and birefringence, based features are significantly efficient in the gem identification process, and if a well-organized gemstone database is available, such features might be sufficient for an accurate identification procedure.

The method is effectively dependent on the organization of the gemstone database, good gem classification as well as considerations for handling special phenomena in some gemstones.

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