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Focus Stacking as a Tool for Enhancing the Detail of Jewelry Items

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Abstract

The article discusses the application of the focus stacking method to improve the detail of jewelry items. The purpose of this research is to analyze the theoretical foundations and practical implementation of focus stacking technology as a means of overcoming the physical limitation of depth of field in macro photography of complex-shaped items, which enables maintaining high informative value in visual materials and reducing return rates in e-commerce. This justifies the raging demand for high-quality content by content manufacturers who create valid justification for this study to enhance customer trust and boost conversion. This paper carries out an analytical review based on 13 sources, including algorithmic studies covering both stages: sharp pixel selection and PSNR assessment, and a comparison between commercial and open-source stacking software packages. This work is novel in its attempt to systematize focus stacking criteria, particularly in justifying the selection of focus step and aperture values that can ensure maximum sensor micro-contrast without diffraction loss, while also providing practical recommendations for forward equipment and lighting choices under modern macro cameras and lenses. The primary results show that using the method, with software merging the sharpest areas of each frame, can create final images having PSNR above 68 dB. This minimizes artifacts such as halos and stepped borders. Strict adherence to shooting and depth map retouching parameters ensures a stable and predictable production process. This article will be helpful for professional photographers, optical engineers, jewelry manufacturing technologists, and e-commerce specialists.

Keywords: *Focus Stacking, Macro Photography, Depth of Field, Jewelry Photography, Micro-Contrast.*

INTRODUCTION

Jewelry macro photography presents specific optical requirements, as the photographer works at scales down to 1:1, where the depth of the sharply rendered space shrinks to fractions of a millimeter: at a focal length of 200 mm and an aperture of f/4 on an APS-C format, it is less than 1 mm, so even slight tilting of the ring results in a large portion of the cut being blurred (Vorenkamp, 2021). The attempt to compensate for this with traditional aperture narrowing quickly reaches the diffraction limit and loss of micro-contrast, while increasing the exposure complicates control of reflections on polished metal surfaces. An additional complication is the growth of the effective aperture. At a 1:1 magnification, the actual light-gathering power of the lens decreases, requiring either more powerful flash lighting or a higher ISO setting.

Focus stacking solves the problem of the physical limitation of depth of field without compromising between detail and diffraction. The method is based on sequentially shooting a set of frames with a micro-shift of the focus plane and subsequently merging the sharpest areas of each image in software. As a result, a file is created where the metal grain, laser engraving, and stone facets are all displayed equally sharply from the nearest to the furthest point of the item. For the photographer, this means the ability to work at optimal apertures of f/8–f/11, preserving the peak level of the sensor's micro-contrast, as well as constructing a predictable production process: the focus step, number of frames, and safe exposure are calculated in advance, which reduces post-processing time. The client, whether a jewelry manufacturer or an online platform, receives visual materials with high informational content: the buyer sees the precise geometry and absence of hidden defects, which increases brand trust and reduces returns. Thus, focus stacking serves not only as a technical trick but also as an economically justified tool that harmoniously links the needs of the artist, the optical engineer, and the commercial customer.

MATERIALS AND METHODOLOGY

The review is based on the analysis of 13 key sources, including academic articles, industry reports, and technical documentation from macro equipment manufacturers. The theoretical basis includes studies on the problems

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of depth of field in macro photography and focus stacking methods: works by Jacobs et al. (2012) describe algorithms for constructing sharpness maps, while Sigdel et al. (2016) explore performance and merging quality using a modified Harris function. Practical recommendations for calculating the focus step and shooting parameters are drawn from the Photo Pills (2025) handbook and reviews of the Canon EOS R7 and Sony α7R V equipment (Canon, 2025; Sony Electronics, 2024).

The analytical approach included the systematization of focus stacking methods in two directions: the algorithmic part — comparing sharp pixel selection criteria (gradient analysis, wavelets, Harris metric) and PSNR evaluation for different merging methods (Jacobs et al., 2012; Sigdel et al., 2016), and the software part — an overview of the capabilities of commercial and open-source packages such as Helicon Focus, Zerene Stacker, and FocusALL with consideration of processing speed on modern processors (Helicon Soft, 2025a; Sigdel et al., 2016). A comparison of apparatus and illumination conditions was also conducted, based on the details from Gitzo (2021) and the requirement for a CRI ≥ 96 to achieve steady micro-contrast (Jefferson, 2022; Bourgi, 2024).

Qualitative synthesis and analysis gave general rules for working out the focus step (0.8 x DoF), giving apertures of f/8-f/11 as the best ones to use since diffraction can be kept low at these values, and ways of post-processing were found which included interactive retouching of depth maps, spot removal of artifacts, and color correction of the original RAW files before stacking.

RESULTS AND DISCUSSION

The method starts with a controlled set of images, each focused on a new plane, until the entire thickness of the item has been traversed. A practical guideline sets the step size to no larger than 80% of the calculated depth of field. This is because PhotoPills, when shooting at 1:1 magnification, outputs a safe step size of 0.8 × DoF and simultaneously indicates that the effective aperture loses approximately two stops of light at such magnification (PhotoPills, 2025). Therefore, even a compact ring requires several dozen frames. Examples from Helicon Focus demonstrate working stacks ranging from 13 to 120 shots, confirming that this range is suitable for most jewelry items (Helicon Soft, 2025a). Maintaining consistent exposure parameters throughout the session ensures stable tonal relationships between frames, simplifying further analysis.

After loading the series, the software aligns the files and builds a sharpness map. Most modern algorithms measure local sharpness through gradients or wavelets and then select for each pixel the image where this indicator is maximal. The version presented in the work of Jacobs and co-authors first extracts the depth map. Then it calculates per-pixel blur, which allows controlling both the expansion and artificial narrowing of the focus zone without noticeable artifacts, as shown in Figure 1 (Jacobs et al., 2012).

Fig. 1. Manipulating depth of field using a focal stack (Jacobs et al., 2012)

An alternative approach, FocusALL, employs a modified Harris response and demonstrates a processing time of less than 10 s for a stack of 1280 × 960 pixel images on an i7 @ 2.8 GHz processor, while increasing the resolution to 2560 × 1920 pixels raises computation time only to several minutes, remaining practically linear concerning the number of input frames (Sigdel et al., 2016).

At the merging stage, the system constructs the final frame using a mask of the sharpest regions; however, halos, depth transitions, and stepped boundaries along the edges are inevitable. As shown in Fig. 2, the Stanford algorithm addresses this by feathering the slice map (Jacobs et al., 2012). In contrast, batch applications such as Helicon Focus or Zerene Stacker offer an interactive retouching brush, enabling the manual replacement of problematic areas with adjacent sharp layers for jewelry facets, where even micron-level displacement of a reflection is noticeable to the eye (Helicon Soft, 2025b).

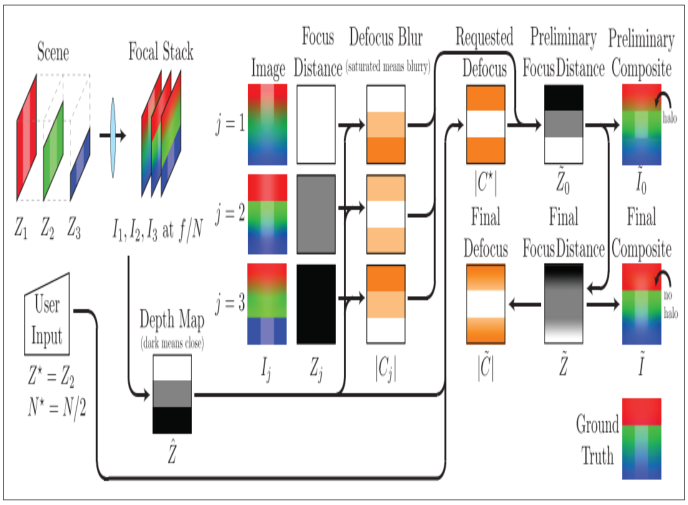

Fig. 2. Focal Stack-Based Depth Estimation and Defocus Correction Pipeline (Jacobs et al., 2012)

Final retouching entails equalizing color temperature across the stack, suppressing noise amplified by repeated interpolation blending, and spot removal of dust particles, which appear in the merge as recurring artifacts. The result is an image with uniformly high detail from the leading edge of the bezel to the rearmost rows of granulation on the shank, based on objectively measured sharpness maps and supported by algorithmic PSNR estimates exceeding 68 dB for FocusALL and 69 dB for the best wavelet methods in laboratory tests (Sigdel et al., 2016).

Jewelry is worked at scales of only a few millimetres, making each facet of the object a separate optical challenge: the flat surface of an oval signet ring measures only 10 × 8 mm, and the common men's size is 14 × 12 mm (Hancocks, 2025), while in micro-pavé rings the diameter of the diamond row starts at 0.9 mm with a shank thickness of about 1.7 mm (Wwake, 2024). At such dimensions, the depth of field remains below one millimetre, even at low apertures. Therefore, without focus stacking, it is impossible to simultaneously render granulation peaks, bezel edges, and internal reflections within the stone, which together form the visual impression of quality.

E-commerce audiences dictate the requirement for complete visual information: surveys show that up to 75% of online buyers make decisions based on image quality (Jefferson, 2022), and 93% of buyers overall consider product appearance a key element of trust, as shown in Fig. 3 (Bourgi, 2024).

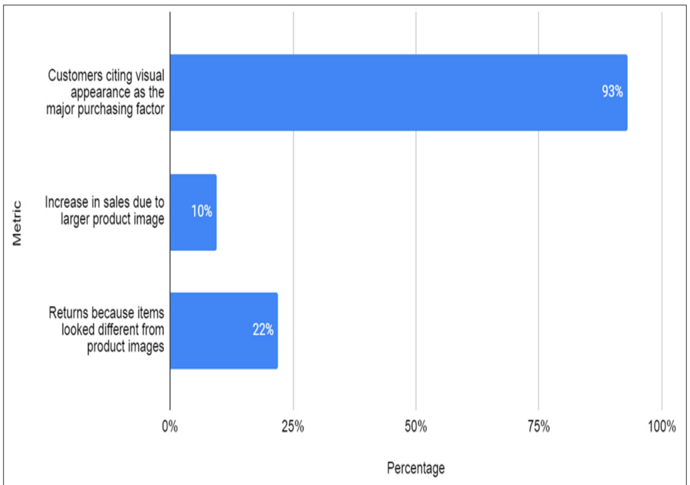

Fig. 3. Impact of Product Images on Sales and Returns (Bourgi, 2024)

Under such conditions, any blur on the claw setting or a missing baguette facet directly reduces conversion, since the user zooms into the image on screen and expects to see high spatial frequencies without diffractive softness.

The economic correlation is measurable: e-commerce platform tests demonstrate a 9.5% increase in sales with larger, sharper product images, while 22% of returns are linked to discrepancies between the real item and its online appearance (Bourgi, 2024). Focus stacking narrows this gap, delivering a technically accurate image that reduces return rates and simultaneously increases conversion, thereby directly affecting the margin of jewelry retail operations.

An effective focus stack begins with the camera and lens, which must already capture the maximum number of spatial frequencies during shooting, since software merging cannot restore details absent from the original frames. At the basic level, a crop-sensor camera with a relatively dense sensor, such as the EOS R7, which has an effective resolution of 32.5 MP, yielding approximately 4 µm per pixel, suffices while retaining system maneuverability on a confined shooting table (Canon, 2025). An optimal configuration utilizes the full-frame 61 MP α7R V, where a 5.4 µm pixel combines with high dynamic flexibility, allowing the brilliance of faceted stones to be revealed without highlight clipping while preserving exposure headroom for the shadows of the item (Sony Electronics, 2024). In both cases, the lens must provide true macro magnification.

To ensure geometric consistency across each shot in the series, the camera-lens assembly is mounted on a high-load carbon tripod—such as the Gitzo Systematic GT3543LS, which supports 25 kg at just over two kilograms of its weight—so that micro-vibrations from the shutter or floor are not transmitted to the frame (Gitzo, 2021). Precise focus shifts are achieved with a motorized macro rail, allowing for the calculation of the number of frames without gaps or overlaps between adjacent layers. The shutter release is handled by a wired remote, whose cable length creates mechanical decoupling so that even during twenty to thirty sequential exposures, no parasitic shift occurs, as detected by the alignment algorithm.

Lighting sets the limit of perceived micro-contrast, so light sources with a color rendering index of at least CRI 96 are used. Through a Bowens mount, softboxes with diffusers and polarizing grids are attached, which soften specular highlights on facet edges while providing controlled reflections necessary to accentuate volume. In the end, such an assembly—a high-resolution camera with macro optics, a rigid support system, a precision focus rail, and high-quality continuous lighting—forms the technical core of the process, where each component minimizes errors that increase post-processing time and thus enhances the efficiency of focus stacking in commercial jewelry shoots.

The preparatory stage begins with a thorough cleaning of the jewelry using a microfiber and an air blower to remove fingerprints and dust. Afterward, the item is secured on a vibration-minimized surface, and the shooting area is covered with a dust-proof dome to prevent recontamination. The camera is mounted on a low-resonance tripod, the horizon is leveled, the sensor and front lens element are degreased, and the color calibration profile is activated even before the first frame, ensuring that the final stack relies on homogeneous source data.

A system of diffused sources forms the lighting, with reflectors arranged to illuminate the piece uniformly, emphasize the stone facets, and simultaneously prevent harsh reflections on polished edges. The color temperature is set according to a reference chart and then locked in place. The exposure is calculated to preserve highlight detail while retaining the metal's texture in the deepest tone. If necessary, a circular polarizer is added to regulate the amount of reflected light precisely.

Shooting is performed at a moderate aperture that provides the greatest micro-contrast before diffraction losses occur, and all exposure parameters, including sensitivity and shutter speed, remain constant for the entire series. The camera is mounted on a focus rail with micrometric feed, and the focus plane is moved in uniform, small steps until the whole thickness of the jewelry is traversed from the nearest to the farthest point. Each shutter release is initiated by a remote cable or via the built-in timer; the electronic shutter eliminates micro-vibrations, and image stabilization is set to static mode.

Upon completion of shooting, the uncompressed files are imported into the stacking software, where they are automatically aligned for scale and parallax. The algorithm analyzes local sharpness, constructs a depth map, and creates the composite image using a mask of maximal contrast gradient values. The operator reviews the transition boundaries and, if necessary, corrects them with an interactive brush to achieve smooth contours without steps between layers.

Final processing includes spot removal of artifacts occurring at highlight edges, color balance equalization across the stack, and noise suppression using a low-frequency filter. Local sharpening gently enhances facet reflections and engraved lines, with a spatial mask restricting this effect to zones of high detail. The resulting composition is saved in an archival format with an extended dynamic range and then converted to an optimized sRGB copy for web publication, ensuring fast catalog loading without loss of critical information on the metal surface and maintaining high-quality settings.

Focus stacking elevates jewelry detailing to a new level, yet the methodology imposes its limitations. The most common issue relates to intense reflections on polished facets and tiny stones. The merging algorithm selects regions of maximal sharpness, but in iridescent metal or on a stone surface, the contrast boundary shifts from frame to frame, producing halos or fine steps in the final image. Avoiding these artifacts requires soft, diffused light, adjusting the polarizer, and spot retouching of the depth map. If the mask is smoothly feathered, transitions between layers become imperceptible, and a uniform lighting field reduces reflectance differences between adjacent frames.

A second group of errors arises from micro-shifts of the camera relative to the object. Floor vibrations, mechanical shutter actuation, or slight touching of the camera body lead to displacement in the series that the focus rail motors cannot compensate for. Software alignment can correct minor deviations, but with significant offsets, the software begins to stretch or compress frames, degrading micro-contrast. In practice, this problem is solved by combining a static platform, a massive tripod, and an electronic shutter. A timer-based or wired-remote release further eliminates transmitted vibrations. When shooting with flash, it is advisable to set a short delay between mirror lock-up and the flash pulse so that residual oscillations decay before exposure.

Finally, at maximum detail, chromatic aberrations become noticeable, especially at the edges of high-density settings and mounts. When frames are stacked, color fringes accumulate, causing a minute purple edge to become a visible multicolored halo. Overexposure adds complexity: a glossy facet clips in one frame, while the adjacent layer, focused elsewhere, preserves texture, resulting in a blotchy area upon merging. The optimal solution is to use an apochromatically corrected lens, select a mid-range aperture where longitudinal aberrations are minimal, and bias exposure toward slight underexposure without altering shadow levels. In the editor, color correction is applied before stacking to remove most false hues in the raw files, and highlights are softened with a local mask, thus preserving metal purity and stone saturation in the final image.

Thus, focus stacking not only overcomes the physical limitation of depth of field, ensuring uniform sharpness from the leading edge to the remotest details of the jewelry, but also guarantees a predictable shooting process through pre-calculated focus steps and frame counts, while maintaining optimal micro-contrast and minimizing artifacts; careful equipment selection and lighting setup further reduce the risk of halos, chromatic aberrations, and noise. The final merging of frames, followed by color and noise correction, yields visual materials that increase customer trust, reduce returns, and directly enhance the commercial effectiveness of jewelry projects.

CONCLUSION

The conducted analysis demonstrates that focus stacking is an effective and economically justified tool for jewelry photography, as it overcomes the physical depth-of-field limitations in macro shooting, preserves optimal sensor micro-contrast, and eliminates the need to stop down the aperture, thereby avoiding diffraction and loss of detail. Sequential shifting of the focus plane and software integration of the sharpest regions from each frame produce images in which the microstructures of metal, laser engraving, and gemstone faceting are equally crisply rendered, substantially enhancing the informational value of visual content for both producers and consumers.

Careful equipment selection and lighting configuration form the technical core of the process: a high-density camera sensor combined with macro optics, a rigid tripod support, a motorized focus rail, and high-quality continuous light sources with a CRI of 96 or higher minimize shooting errors and accelerate subsequent post-processing. Focus steps, frame counts, and safe exposure settings are pre-calculated so that tonal relationships between frames remain consistent from one to another. This allows the operator the opportunity to optimize the session without having to stop and make changes constantly.

Halos and stepped boundaries at depth transitions, multi-interpolation noise, and even chromatic aberration at high-density setting edges are typical artifacts that come with the methodology. Light, diffused lighting with a slight amount of spot retouching on the depth map helps minimize these artifacts. An apochromatic lens further minimizes such artifacts, while pre-stack color balancing of raw files eliminates false hues and preserves reflections.

The economic impact of focus stacking is most evident in increased conversion rates on e-commerce platforms and reduced returns. High-quality images with uniform detail support buyer confidence and minimize discrepancies between the online appearance and the actual product. Ultimately, the methodology delivers not only technical superiority in visual content but also a direct positive effect on the commercial efficiency of jewelry retail.

In this way, focus stacking serves not merely as an auxiliary technique but as an integral element of professional jewelry photography, harmoniously uniting optical, technological, and economic aspects to ensure process reproducibility, high informational content in images, and mitigation of operational risks.

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