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A Curious Conundrum; The State of Holographic Portraiture in the 21st Century

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Abstract. The technology of producing (true) hologram portraits was first introduced in the late 1960's. From this time, a number of individuals and organizations worldwide have specialized in providing holographic portraiture services with varying degrees of achievement. Yet today, some 45 years later, holographic portraiture remains an obscure and niche form of displaying an individual’s likeness. Despite all of this technology’s promising and unique attributes, and the astonishing fact of holography being the most accurate and realistic form of imaging available today; true holographic portraits continues to be a form of portraiture largely unknown to the general public and has never achieved large-scale commercial success.

This paper will present a brief history of holographic portraiture, designating the different types of 3-D hologram portraits available today, and their uses. Emphasis will be given to true holographic pulsed portraiture in which the subject itself is recorded holographically using high-energy pulsed lasers. Possible cause and effect for explaining the present demise of this type of portrait making will be discussed along with recent advancements and future developments in this fledgling field which could ultimately lead to a “tipping point” in large-scale consumer and commercial awareness and desirability of the medium.

The author will share his experiences in operating pulsed holographic portraiture studios for over the last 15 years including the vision of a new type of holographic portrait studio for the 21st century which he hopes will attain the level of success enabling a next generation of commercially viable holographic portrait studios for the future.

Keywords: Holographic Portraiture, Hologram Portraits, 3-D Portraits, Pulsed Holography, Pulsed Portraits, Portraiture Holography, 3-D Imaging, Life Holography

1. Introduction
The practice of representing the physical and psychological likeness of an individual is as old as art itself. The principle methods of portrait making; e.g. painting, sculpture, and photography, have long been used successfully to immortalize one’s “essence of being”. The mystical, magical, and spiritual nature of the portrait has long been associated and accepted within each of these methods.

A relatively recent newcomer, holography and it’s unique ability to accurately record and reconstruct original light wave-fronts, particularly lends itself to this form of artistic endeavor. It is exactly this capability of capturing the “wholeness” of an individual’s likeness that makes hologram portraiture so alluring and attractive.
Yet, despite some forty plus years on the scene and even the recent mis-placed hype of the “Tupac hologram” among many other more substantial achievements, holographic portraits remain largely undiscovered and out of the mainstream public’s eye. Why is this so? How can it be that the most accurate method of reproducing one’s likeness (and thus by its very nature, potentially the most emotional) is also by far the least sought after and under-utilized? What forces and factors are involved, and how and when will this new form of portraiture evolve to a wide-spread audience? This paper will attempt to bring to the forefront some of the existing factors and social conditions that have limited the large-scale success of this method of portraiture to date.

2. Classifications and History
Hologram portraits are generally classified into two distinct types. Pulsed portraits are classically referred to as true hologram portraits, in which the original image-capture (H1) and subsequent final copy (H2) are produced using wave-front recording. In this type of hologram, high energy, extremely short exposure ruby or frequency-doubled neodymium-based pulsed lasers are used to successfully record the living subject. Multiplex and/or stereogram portraits are holograms in which the original image capture is generated photographically (P1) and are subsequently utilized in the production of a final H1 and/or H2 hologram (usually a rainbow hologram) with standard continuous wave lasers. A recent sub-category of this type worth mentioning is the now commercially available direct-write, digital “dot-matrix” technology in which the initial image-capture can be generated by digital photography and/or computer generated content and then directly “printed” as a full-color reflection hologram using either CW or pulsed RGB lasers (GEOLA Digital uab Vilnius Lithuania, Zebra Imaging Austin Texas USA, Ultimate Holography Bordeaux France). This paper will principally be referring to the completely holographic method of recording, known classically as “pulsed portraits”.

The first-ever pulsed hologram (self)portrait was produced by Lawrence D. Siebert while he was working as an electrical engineer for the Conducor Corporation on (what must have been a scary) Halloween night in 1967. Since this time, many successful holographers and artists have produced hologram portraits using both pulsed; ex., Margaret Benyon, Hans Bjelkhagen, Richard Bruck, Bruce Nauman, Peter and Ana Marie Nicholson, Edwina Orr, John Webster, and stereogram techniques; ex., Lloyd Cross, Mark Diamond, Larry Lieberman, Jason Sapan, among others.

A historic example of a pulsed transmission hologram portrait was done of Dennis Gabor (1971, R. Rinehart) as homage to Dr. Gabor’s Nobel Prize that year for the invention of holography. Since then hologram portraits have been produced of US Presidents Ronald Reagan (P), Bill Clinton (S), Barack Obama (D), and Queen Elizabeth II of England (S) and include many other notable heads-of-state figures of our times. Yet if a sampling where taken, most of the public would report not being aware of these holograms and would be hard pressed to

1 By the term “hologram portrait”, it is defined here as any type of portrait that uses the science of wave-front recording and reconstruction known as holography, either partially or wholly in its method of producing a three-dimensional image of an individual’s likeness. The author expressly wishes to distinguish the art of true holography from other popular alternative 2-D and 3-D projection and “Pepper’s ghost” effects and techniques that inaccurately use this terminology.

2 It should be noted that the majority of “pulsed” holographers do not prefer this term for their profession, justifiably citing portrait photographers are not sub-termed “flash” and “available light” photographers.

3 Denotes- (P) pulsed hologram portrait, (S) stereogram hologram portrait, (D) computer-generated digital hologram portrait.
remember an instance of seeing any hologram portrait (albeit possibly the mislabeled “CNN” and “Tupac” variety).

Due to the strict requirements initiated in holographic recording, original holographic image-capture (H1) of living and/or moving things can only be accomplished with extremely short exposure, high energy pulsed lasers. Pulse line-widths in the 25-50 nanosecond range and energy levels of between 1-5 Joules are acceptable for currently available holographic silver-halide recording emulsions such as the Slavich VRP-M for green pulsed holography. Lasers can be found (albeit still relatively expensive) in both the classic ruby or the newer neodymium crystal type and are capable of producing high quality, large-format pulsed holographic portraiture. Optical schemes for the recording of living things as true holograms has not changed much. Multiple diffuse object beams allow maximum creative lighting control for the holographer. When using these types of Class IV lasers, extreme care must be maintained to keep maximum permissible exposures of radiation well below the levels set forth to eliminate ocular risks to the subject(s).

The majority of pulsed hologram portraits made to date have used the ruby crystal rod for light amplification simply because this type of laser happens to be the very first laser invented, and also because many of the original pulsed ruby lasers designed for holography (JK Lasers, Lumonics 1970's) are still around and functional today. The principle disadvantages of using the pulsed ruby laser for holographic portraiture is its output wavelength at 694nm. The deep-red color of this wavelength is at best difficult to use for the imaging of subjects as this color does not reflect well and permeates the outer layers of human skin producing a “glowing effect” if suitable make-up is not instituted. Other disadvantages include the difficulty of keeping the laser properly tuned and aligned to the high optical beam characteristics required for display holography and often the additional need for continuous-wave vibration controlled laser recording systems for the final H2 reflection image transfer and the added costs associated with such. This said, outstanding hologram portraits have been made with this laser design. What is considered by many as one of the finest examples of hologram pulsed portraits of all time, “Lucy in a Tin Hat” (1987, Patrick Boyd) was produced with this original laser design.

Green-based pulsed laser holography using the frequency-doubled neodymium family of lasers (YAG/YLF) first appeared in the former Soviet Union in the late 1980's. In the USA, Ron and Bernadette Olson (Laser Reflections, Poulsbo, Washington) were the first to incorporate this laser design into a holography laser using military surplus optics to successfully produce hologram portraits. The advantages of the Nd:YAG/YLF laser is primarily improvements/corrections in the addressed disadvantages of the ruby, i.e., better reflecting green wavelength light, vastly improved reliability and stability, and the fact that final H2 reflection copies can be produced with the same laser system. Today it is generally accepted that frequency-doubled neodymium-based pulsed holography lasers are the superior choice for monochromatic, high definition pulsed portraiture.

It was the initial viewing of this hologram in 1990 that started the Author’s life-long love affair with holographic portraiture.

A interesting note to this trend is the complete turn-around of commercially available recording materials for pulsed holography, with red pulsed sensitive emulsions currently in short supply. All of the major photographic film suppliers including Agfa, Ilford, and Fuji no longer manufacture holographic materials, although some of these emulsions are still available in limited supplies on the surplus market.
3. Technical Advancements

Despite the extremely unique true three-dimensional image reproduction qualities, and ultra-high resolution nature of display holograms, commercial pulsed display holography continues to struggle to gain market share and become a commercially successful business model. Companies such as GEOLA Digital uab, and Ultimate Holography have been leaders in the manufacture of specialty pulsed holography lasers and camera systems specifically designed for pulsed portraiture applications. GEOLA Digital uab continues to produce a line of commercially available pulsed neodymium holography lasers in addition to complete turn-key pulsed holography studio and portable systems that are used world-wide within the industry. These two companies have additionally contributed greatly to the advancement of designing and making commercially available the specialty film and glass plate fine-grain AgBr emulsions (VRP-M, Ultimate) required to successfully manufacture high quality pulsed display holograms.

Due to the extremely short exposure times of pulsed lasers and the effect known as latent-image fading, special developers and processing techniques must be utilized for the manufacture of pulsed holograms. Photographic techniques such as hypersensitization and latensification are used to increase the light sensitivity and reduce the reciprocity failure tendencies of classically slow fine-grain holographic emulsions. The holographic developer SM-6 (Bjelkhagen/Wesly) is now considered the defacto standard for pulsed laser holography. It has been observed that slight reductions in the concentration of phenidone in this developer can be fine-tuned to improve the overall signal to noise ratio of finished holograms while obtaining only a slight decrease in diffraction efficiency. Bleaches common for pulsed holography include multiple versions of the rehalogenating type, such as the PBU-Amidol (Bjelkhagen-Phillips) and Ferric nitrate (Phillips) formulations. Post processing emulsion shrinking color-control techniques have been developed for greatly improving the aesthetic qualities of monochromatic green pulsed reflection holograms using varying concentrations of d-Sorbitol or Citric Acid solutions(Olson-Blyth). Although currently impractical for daily use, the multi-step processing technique known as silver-halide sensitized gelatin (SHSG) which renders silver-halide emulsions as “grain-less” with high diffraction efficiency and low scatter similar to dichromated gelatin (DCG) has been shown to produce pulsed display holograms of exceptional brightness and clarity. Further advances in the chemical processing/recording materials will continue to improve the over-all quality and archival properties of pulsed holograms in the future.

In hologram reconstruction, low-wattage, narrow-band LED lighting solutions are now available in lumens sufficient to adequately illuminate standard 30x40 cm and larger monochromatic reflection holograms with higher contrast and increased sharpness over depth-of-field. Additional benefits include lower operating costs, greatly increased bulb life, and reduced heat generation compared to standard halogen spot lamp lighting.

Recently research has begun by the GEOLA Group and others towards the development of two (RG), and ultimately, three (RGB) color high-energy pulsed holography lasers based on the second and third harmonic generation of the neodymium family of lasers. The commercialization of a two-color high energy pulsed holography laser would make possible natural color skin tones along with multi-chromaticity scenes. This advancement would compare in significance to the commercialization of the first photographic portraits from black and white to color.

Ed Wesly relates the discovery of this developer by accident. A lab assistant at the time (Sal), mis-measured the prescribed amount of phenidone (6 grams), and “Sal’s Mistake-6 was invented.
4. Aesthetics
By the view of the author, current limitations of pulsed display holography such as specific lighting playback requirements, limited viewing angle, and monochromaticity of imagery have little to do with the lack of commercial success of the medium. Moreover, it is felt that factors such as the high-cost of imaging, narrow exposure to within society, lack of a successful marketing strategy, and the complex physiological perceptions of the public play a larger role in the limitation of large-scale commercialization of holographic portraiture. The general public’s changing perceptions (and ultimately the desirability) of hologram portraiture is a complex subject that warrants further investigation. Historically, one can certainly compare and see similarities within the early days of photography, when initially a substantial percentage of the population related the photographic portrait with the “capturing of one’s soul”. “Spooky” and “scary” are two adjectives that are used far too often by some upon witnessing a pulsed portrait for the first time.

From the author’s experience in the direct marketing of holographic portraiture over the last 20 years, it can be noted that this same type of adverse emotional state towards the “intense realism” and “stillness” of pulsed portraits is experienced by a significant portion of the population today. That said, clearly there is also a growing (largely untapped) audience which can envision the benefits of commissioning a personal pulsed portrait of a loved one and upon completion relate this as a deeply positive emotional experience.\(^7\)

Of course just as within the other classical portraiture mediums, successful commercialization is largely achieved by producing aesthetically pleasing portraits. Holographic portraiture is no different in this regard and multiple factors have contributed in a less than exemplary record for pulsed portraiture. Part of the reason for this is the extremely high-costs associated with holographic recording materials. In an age of digital photography, where endless shots and poses can be recorded during a portrait session, pulsed holography must balance a rather limited “contact sheet” from which to select versus the steep cost of it’s recording materials. Another factor lies within the sterile laboratory and eerie safe-light conditions of the conventional pulsed holography studio. As can be imagined, small children are especially difficult to image in this environment.

The absolutely “pure” and unretouchable nature of holography would normally be perceived as a disadvantage for other imaging mediums, however with pulsed portraits it can be used to an unique advantage. The “ultra-accurate” aspect of pulsed portraiture allows the client of this service the

\[\text{Figure 3} \text{ "Nathan & Carolyn" Author's children, pulsed transmission hologram. (1993, Bjelkhagen, Bruck)}\]

\[\begin{array}{|c|c|c|c|c|c|}
\hline
\text{Technique} & \text{Cost} & \text{Versatility} & \text{Aesthetics} & \text{Uniqueness} & \text{Realism} \\
\hline
\text{Sculpture} & \text{High} & \text{Low} & \text{High} & \text{High} & \text{Low} \\
\text{Painting} & \text{High} & \text{Low} & \text{High} & \text{Medium} & \text{Low} \\
\text{Photography} & \text{Low/Medium} & \text{High} & \text{Medium} & \text{Low} & \text{Medium/High} \\
\text{Holography} & \text{High} & \text{Low} & \text{Low/Medium} & \text{High} & \text{High} \\
\hline
\end{array}\]

\[\text{Figure 4} \text{ Factors determining the marketability of various portrait techniques.}\]

\(^7\) In 1997, Forth Dimension Holographics completed a marketing study on the perceptions and desirability of holographic portraiture. 244 participants filled out a short questionnaire while analyzing a pulsed hologram portrait. Copies of this study are available upon request.
assurance of knowing their family keepsake’s likeness is exact in the greatest detail possible. Literally a moment in time captured forever. That said, correctly designed H1/H2 transfer optical recording schemes must be strictly maintained in order to not introduce three-dimensional distortions of the subject which result in ghastly reflection hologram portraits!

To reduce the material costs, some pulsed holography studios have initiated the on-site manufacture of film/plates (Laser Reflections/Forth Dimension Holographics) in which lower cost/higher quality film emulsions are permanently laminated to glass prior to exposure. This results in a substantial reduction in material costs allowing for more H1 transmission proofs to be made during a portrait session while also achieving the blemish-free glass plate quality required particularly of H2 reflection holograms.

The GEOLA Group has been conducting research in the manufacture of high-speed, large-format shutter systems in which a light sensitive holographic plate is “pre-loaded” in a light safe chamber in much the same way as early photographers did with photographic plates. The shutter is triggered to fully open within a few milliseconds around the nanosecond laser wavelength pulse window. This enables the holographer to pose his clients in an ambient light environment, greatly easing both the subjects themselves and the holographer’s task at hand.

5. Authors Personal Journey
In 1992 Forth Dimension Holographics (FDH) was started as a small hologram gallery/retail store in the quaint rural tourist village of Nashville Indiana. From the start, the author had the vision of operating a specialty pulsed portraiture studio in this locale. While attending the 6th International Symposium of Display Holography, the author was introduced to Dr. David Ratcliffe and his team of Russian scientists known as “General Optics Laboratory” (GEOLA). During the conference this company introduced their new line of pulsed lasers and holography studio systems. This meeting set in place the author’s lifelong commitment to the advancement of pulsed holographic portraiture.

In 1999, FDH imported the first operational GEOLA GP-2J (now designated the HS-2) and opened a pulsed holography studio specializing in portraiture. During the next 10 years, over 200 pulsed portraits were commissioned at the facilities in Indiana. In 2003, a satellite GEOLA pulsed holography studio was installed in St. Charles Missouri. In 2008, FDH was forced to close its Indiana pulsed holography studio operations due to the poor economic climate. That same year, the author was contracted to operate part-time the pulsed holography studio of Ron Olson (Ron Olson Holography) in Las Vegas Nevada. This operation also subsequently closed, and the studio was moved to Poulbo, Washington (Laser Reflections) where it is operating today. FDH is currently completing it’s pulsed portraiture commissions at the St. Charles Missouri satellite location.

Now spanning 15 years, FDH has been the North American distributor and representative of The GEOLA Group. FDH anticipates opening a newly remodeled holography center in southern Indiana with both full-service analog pulsed, and full-color digital hologram production capabilities in the first quarter of 2013.
6. Future Directions

Recently there has been a renewed interest in holography’s purest form i.e.; transmission holograms (H1). In this form of display, with the correct laser wavelength characteristics for reconstruction, an exact 3-D copy of the original subject is achieved. FDH is currently developing an integrated free-standing commercial display in which low-power CW lasers with simple beam-cleaning/folding optics are used. This will be marketed as an “add-on” sale to existing/new reflection pulsed portrait customers. The unique “magic window” qualities of this type of hologram offer the public a completely different emotional experience than a conventional reflection hologram portrait. This is as real as it gets.

Although not comparable to 1:1, high-definition, true 3-D image-capture pulsed portraiture, interesting hologram portraiture avenues have recently opened with the aforementioned new digital hologram technology. Using simple digital devices such as cellphone cameras and web-cams, companies such as GEOLA Digital will produce small, economical, full-color stereogram hologram portraits for anyone who electronically sends them their content. Combining more advanced digital photography equipment such as the GEOLA Holo-Cam in conjunction with a continued direction of smaller and smaller holo-pixel resolutions will enable conventional photographers to offer larger, higher quality custom full-color hologram portraits to their clients with interesting effects such as animation and CGI backgrounds. Indeed it is now possible for the first time to enlist the talents of computer 3-D modeling artists to produce a photo-realistic hologram portrait of the deceased.

7. Conclusions

The future of holographic portraiture is largely an uncertain one. Pulsed holographers continue to remain a very small group (as is reflective of display holography in general). With continued dedication and education, and a little patience, the time may be nearing where the public’s awareness, perceptions, and appreciation of a true holographic likeness coincide to produce a watershed event in which holographic portraiture becomes a commercially sustainable industry.

FDH’s anticipated new facilities will reflect this approach and be attuned to a next-generation clientele that will bring with them a new level of conditioning to, and acceptance of, new personal technologies such as holographic portraiture. The importance of using pulsed holography as an archival tool today cannot be over-stressed. Many current figureheads of our society deserve to be chronicled for historical record. Can you imagine pulsed holographic images of... The Dali Lama..., Nelson Mandela..., Stephen Hawking..., Steve Jobs..., can you imagine? We as a society currently have obtainable to us, nothing less than the ability to store and display the most accurate and detailed reproduction of an individual’s likeness possible with today’s technology. And we are vastly under-utilizing this imaging tool available to ourselves and for the benefit of future generations.

There is a need for more educational institutions, such as the HOLO-Center (Seoul, South Korea) and Ohio State University (Columbus Ohio) with their existing pulsed laser facilities, to continue to instruct and educate the new breed of holographer with the skills needed to evolve to the next level of commercial availability of the medium. Only by continued public exposure and awareness, woven within the complex fabric of an ever-changing social environment will holographic portraiture reach a “tipping point” of commercial success. It is in the view of this author and a growing number of others that this is simply a matter of “when” and not “if” this will occur.

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