Implications of photography's computational turn for visual methods

Implicaciones de la fotografía computacional para herramientas de apoyo a los métodos de investigación visual

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ABSTRACT

Drawing on the research methods developed during an exploratory visual analysis of global photojournalism during COVID-19, this paper examines the opportunities for employing metadata (from capture, context, and publishing) in visual research and the implications of emerging computational photography. Metadata is critical for facet analysis of visual datasets and exploratory visual analysis, as well as assessing image validity, provenance, and capture and publishing contexts. In the case study dataset, only one-third of the photojournalism included embedded EXIF metadata, associated with the editorial workflows of source photo agencies, while other metadata was rare (such as geospatial data) or absent (IPTC metadata). Emerging imaging approaches present both opportunities and challenges for visual researchers to engage with how our visuals worlds are captured, selected, and represented. As imaging techniques rely on rapidly evolving and conceptually

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opaque sensing and algorithmic techniques, visual researchers should prioritize engaging with visual tools and standards development.

Keywords: exploratory visual analysis, metadata computational imaging, researcher shaping of technology, photojournalism during COVID-19.

RESUMEN

Basándose en los métodos de investigación desarrollados durante un análisis visual exploratorio del fotoperiodismo global durante el COVID-19, este documento examina las oportunidades para emplear metadatos (de captura, contexto y publicación) en la investigación visual y las implicaciones de la fotografía computacional emergente. Los metadatos son fundamentales para el análisis de facetas de conjuntos de datos visuales y el análisis visual exploratorio, así como para evaluar la validez de la imagen, la procedencia y los contextos de captura y publicación. En el conjunto de datos del estudio de caso, solo un tercio del fotoperiodismo incluía metadatos EXIF integrados, asociados con los flujos de trabajo editoriales de las agencias fotográficas de origen, mientras que otros metadatos eran escasos (como datos geoespaciales) o estaban ausentes (metadatos IPTC). Los enfoques de imágenes emergentes presentan oportunidades y desafíos para que los investigadores visuales se comprometan con la forma en que se capturan, seleccionan y representan nuestros mundos visuales. Dado que las técnicas de imagen se basan en técnicas algorítmicas y de detección conceptualmente opacas y que evolucionan rápidamente, los investigadores visuales deben priorizar el compromiso con las herramientas visuales y el desarrollo de estándares.

Palabras clave: análisis visual exploratorio metadatos, imágenes computacionales, investigador dando forma a la tecnología, fotoperiodismo durante la COVID-19.

INTRODUCTION

In *The Engine of Visualization*, Maynard (2000) summarized the photographic process as the inscribing of visual information on a photosensitive medium. This no longer applies. The pervasive use of computational techniques from capture to distribution raises ontological implications for visual research methods when what photography is and what it produces are in flux. Computational photography is an evolving term meaning the use of "sensing strate-

gies and algorithmic techniques to enhance or extend the capabilities of digital photography" (Adams et al., 2010). In computational photography, image data and information from sensors and activities are transformed to create simulative images (Lehmuskallio, 2016) and augment the experience of photography from capture to distribution. Photojournalist and digital media editor Ritchin wrote in *After Photography*, published on the eve of computational photography, that "we are only beginning to grapple with many of the implications of the digital revolution" after two decades (Ritchin 2010, p. 41); this applies to our ability to develop methods and tools for exploring and researching datasets of digital imagery.

In the 2020s, computational techniques are now an integral part of image capture, viewing, and distribution, with important implications for visual researchers. Beyond the potential for creating synthetic imagery, computational techniques capture images that no longer take place at a precise moment selected by the photographer. A "photograph" might be image data over time (a "live photo") or the "best" frames selected from many options, determined and annotated by computational analysis of image data or a video stream. It is not only moments that are now fungible and no longer decisive; just about *everything* can be re-determined—and the decision-making processes themselves are opaque and malleable. Images taken with light field cameras may be refocused after capture to emphasize different subjects in the frame. Images synthesized from 360-degree visual data can be recomposed to show any angle, or multiple ones. Mobile devices now present algorithmically curated discovery within, and engagement with, our personal photo archives that include highlighting individual images and suggesting edits based on location and aesthetic analysis, as well as sharing based on facial recognition of the subjects. In fact, computational techniques may no longer take a single image but rather sense, analyze, store, and recommend disseminating image data directed by a combination of automated and manual techniques.

Given this reimagining of visual imagery creation, contextual data regarding its capture, processing, and distribution are critical for assuring proper documentation and research reproducibility. This is particularly critical for research as well as photojournalistic and documentary contexts, in which recording and analyzing the capture context, processing pipeline, and provenance of visual data is essential for both validation of the visual content and also for integration with other data sources.

To address some of these concerns, in February 2021 the Coalition for Content Provenance and Authenticity (C2PA) began developing technical standards for "producers and custodians of any given content to assert, in a verifiable manner, any information they wish to disclose about the creation of that content and any actions taken since the asset's creation" (C2PA, 2021). Of the four stakeholder groups in mind, the closest match to visual researchers

is the "Content consumers" group, representing those who might "wish to understand the process by which the content was created."

The C2PA's goal represents only a small first step: Computational imaging changes the relationship between photographer, viewer, and researcher. Photography remains at the core of our efforts to document and express our world. But emerging is a vision of photography that shifts from concrete workflow to abstracted pipeline, from tangible photographic results to data (image and process) that can be analyzed, transformed, and augmented. The ability to understand, innovate, and research using visual materials is increasingly constrained to those comfortable with computational practices. It is important, then, to consider computational thinking in the context of visual research methods and tools.

To explore this topic, in the following sections I summarize the methods developed during a case study researching the professional practice of, and challenges facing, visual journalists during the COVID-19 pandemic, and then analyze the implications for research. This visual journalism context is important because of the pandemic's global and historical nature, its implications for documentary practice, and because it takes place during the early stages of the transition from digital to computational visual technologies. Visual journalism standards, not unlike those of researchers, are negotiated through professional pressures including accolades and cautionary tales. Members of these communities negotiate the implications of cases in which they suspect a professional of exceeding standard editing guidelines (such as a crop or color correction), influencing or posing scenes, mis-representing contexts, or manipulating visuals for aesthetic or narrative reasons (Ferrucci, Taylor, 2019). While photographers have long grappled with the implications of new technologies —including of color photography, digitalization and digital transmission of images, and video capture (Becker, 1991) and digital manipulation (Mäenpää, 2014)— the intangible and rapidly shifting nature of computational approaches now raises additional problems for photographers and visual researchers.

A key insight of Becker's work is photojournalists' diminishing sense of control over both the images they produce and the innovations they interact with professionally. Similarly, recent surveys of photojournalists found that the pressures and change of digital workflows increased risks to their health, financial security, and careers (Hadland *et al*., 2016). Ritchin has also noted concerns about image authenticity and technological deskilling among photographers, but also of the potential for digital technologies to better support photographers, publishers, and viewers in presenting and navigating images using "linked, dynamic, node-like photography, a hyper-photography." Interactive contextual and related information could be accessed by new presentation formats that take advantage of the metadata gathered during capture and editorial workflows (Ritchin, 2010, pp. 72-3).

CASE STUDY

Did visual journalism norms shift during COVID-19?

I will use a specific project to explore implications of computational photography for visual researchers. The project's goals explored visual journalism practices before and during after the global COVID-19 pandemic by comparing matched sets of global visual journalism presented in *The Atlantic*'s "Photos of the Week" photo collections published in 2019 and 2020. (While this case study focuses on photojournalism published in this prominent U.S. publication, the original images were captured by photojournalists worldwide and distributed by news organizations with global operations). The rationale for the study is that visual journalism struggled to adequately represent the rapidly and unprecedently changing world during the pandemic.

Among the news gathering professions, photojournalism was particularly risky for photographers and subjects. While reporters could conduct telephone or video interviews, the pandemic limited photojournalists' ability to travel, document interactions among people, and engage closely with subjects in their own contexts. Access to locations essential to the story were severely constrained to protect the health of photographers and their subjects and to manage the reputations of the authorities involved. Limited availability of personal protective equipment (PPE), concern about social distancing, and the need to protect privacy further complicated visual coverage. Among media practitioners, these concerns disproportionally affected photojournalists: In the United States, for example, the only media organization to withdraw its participation in a student journalism award for COVID-19 coverage was the U.S. National Press Photographers Association (NPPA), over concerns about incentivizing risk among the competitors.

As the pandemic unfolded, it presented challenges as a visual story as well. Rather than a single catastrophic moment or planned spectacle, day-to-day visual coverage typically showed little change, with photojournalists struggling to balance aesthetics of a scene with its news value. Visual contexts that were initially novel and stunning became mundane as the pandemic spread globally and countries encountered first, second, and subsequent waves. For example, a striking image by Italian Associated Press (AP) stringer Luca Bruno early in the pandemic of a priest near Milan offering mass to photographs of his absent congregation highlighted the community impact of COVID-19. Nearly identical images of priests in San Jose, Costa Rica and Curitiba, Brazil captured several weeks later were distributed on the Agence France-Presse (AFP) newswire as "Topshot" (recommended) images. Entire categories of images shot around the world were duplicative; for example, one blog listed 16 photo collections published on the topic of empty architectural spaces. In this case the images were

novel because the contexts they showed were authentic. Yet they were also familiar because visual media projects such as Ross Ching's *Empty America* had shown similar manipulated scenes years earlier.

By February 2021, British journalist Helen Lewis asked "Where are the iconic COVID-19 images?" (Lewis, 2021) with the rationale that: "We need photographs of this pandemic because we need to remember it *collectively*. We need to fix the coronavirus crisis in our minds… [w]e must remember the scale of the challenge…and remind ourselves which … groups rose to the occasion, and which did not." This article resulted in an uproar from practitioners offended that Lewis did not consider the tremendous challenges covering the pandemic, that individual "iconic photos" were inappropriate for summarizing such a complex story, and that the diversity of compelling photographs captured worldwide were overlooked. During the initial months of the pandemic, photojournalists and editors familiar with difficult conflict coverage discussed additional concerns and strategies for COVID-19 assignments in online forums and presentations. Photographers reported staying further away from their subjects than normal, using fewer and longer focal length (telephoto) lenses, and using recent technologies such as drones and remote systems. They reported meeting their subjects outdoors, at a safe distance, and using protective barriers creatively. They travelled less, staying closer to home, and focusing more on local and personal projects.

Seeking to better understand photographic practice in a global context in which many thousands of photojournalism images are captured each day, I developed a metadata-focused dataset for exploratory data analysis using a curated subset of global photojournalism containing one year before and the first year of the COVID-19 pandemic. My goal was to use this dataset to explore patterns of visual practice before and during the pandemic, and to identify implications for future research that must engage with emerging computational photography.

The Atlantic's Photos of the Week: A global overview of photojournalism

The source for the dataset was the "Photos of the Week" collections in *The Atlantic*'s on-line photo section prior and during COVID-19. These collections use professional global photojournalism and are influential in terms of audience size and scope and are presented in a manner that facilitates automated access to the photographs and (some of) their metadata. Photo editor Alan Taylor curates *The Atlantic's* web photos section using several major wire services including AFP, the AP, Reuters, Getty, and other sources distributed by Getty that include the Turkish state-run news agency Anadolu, Barcroft, Feature China, and pool images. These collections are widely linked and shared via social media and popular online aggregators in the U.S.; *The Atlantic* had "87 million unique visitors to the site, and more than 168 million pageviews" for the entire site at the beginning of the pandemic (Scire, 2020).

Each Friday Taylor posts 35 images that summarizes global photojournalism from the previous week. In addition, he publishes separate collections covering major news stories and events using different photographs; during the pandemic additional collections focused on specific countries particularly affected by COVID-19 and specific visual themes related to its coverage. Taylor focuses on a global, large-format, and aesthetic perspective that both incorporates and challenges the norms of visual journalism and, in my interview with him for this project, he confirmed that he spends "hours every day looking at almost every single photo that comes across AP, Reuters, Getty, AFP. I'm looking at between, you know, several thousand to tens of thousands of photographs every day" (personal communication, 2021). Taylor's workflow and presentation format exposes more visual metadata about the displayed photographs than most media sites, possibly due to his extensive background in information technology.

Methodological considerations

To examine both the visual practice, project, and editing, I created a dataset for exploratory visual analysis following the Tidy Data approach (Wickham, 2014) to combine the results of several data tools. The resulting "Photos of the Week" dataset contained records for each photograph published in these collections during 2019 and 2020; records in that dataset included metadata published with the image (photographer, source agency, date captured, data published, location), EXIF metadata embedded in the photograph itself, and extra fields for automated and manual image classification and notes.

I created these datasets using three main steps: First, I archived the images in the "Photos of the Week" collections in sequence while retaining their metadata. For each collection in 2019 (n=50) and 2020 (n=50), I created scripts using Google Sheets commands to extract each photograph's index number, photographer, source, and caption as published. Separately, I archived the images in a structured directory, resulting in a total of 3,499 images (100 collections of 35 images each; one collection contained only 34 images). I extracted all available metadata from the image file using PhotoMechanic 6's text exporter and joined it to the main data set. In many cases, as discussed below, metadata was not available.

Second, I used facet analysis (in OpenRefine 3.4.1) and pivot tables (in Google Sheets) to identify outliers, errors, and patterns to explore further. For example, two images in 2020 were mislabeled a year earlier, based on searches of the original sources. Third, to explore the potential of computational techniques, I attempted to use the MobileNet Image Classification Convolutional Neural Network (CNN) via Retrobatch 1.4.3. This model, designed for efficiency, is trained to classify the dominant object in an image. My goal was to automate scene identification, but the default consumer training model proved inappropriate for

identifying key visual components of COVID-19 news photography, including masks, health, funeral, and aerial scenes that were probably too novel.

Discussion

The resulting datasets and experiences created raised important methodological potential and challenges. My key finding is that an organized, cleaned, and faceted "Tidy Data" image database combining publication, EXIF, and visual classification data and notes has tremendous potential for exploratory visual research. My dataset enabled me to:

- Rapidly compare the locations of photographs published in 2019 and 2020 by photojournalists whose work was most often selected for publication.
- Visualize and compare, using location data, these photojournalists' travel patterns during these two years.
- Compare capture settings such as lens and focal lengths as a proxy to determine if photojournalists maintained a safe distance from subjects.
- Summarize coverage of photojournalism topics, based on visual data and descriptors in the embedded caption field.
- Explore inequities in global photojournalism coverage and practice via photojournalists' demographic information and home base (ascertained via social media) and regional coverage intensity.
- Explore patterns in Taylor's photo collection editing using metadata captured from the published webpages.

This research served as the first stage of the iterative process designing methods for researching photojournalism during the COVID-19 pandemic and as photographers resumed their pre-pandemic routines. Initial results suggest that subjects, topics, and location were less varied during the pandemic, while practices and capture decisions identifiable through image metadata remained generally consistent.

Visual metadata are essential for creating and exploring datasets, as Fred Ritchin's "hyper-photography" proposal mentioned, and verify authenticity, as suggested by C2PA. This exploration of metadata from published photojournalism during COVID-19 found that public-facing image metadata is inconsistent and unreliable even when it is available. Metadata characteristics depend on the individual capture system and the entire capture-to-dissemination process: In other words, different sources and provenance pathways provide different metadata records that posed challenges for combining and comparing images. In this example, geolocation data was only included for a few photographs, usually those captured using

DJI quadcopters, and compass headings in none; this contrasts with amateur photographs captured by mobile phone camera apps that include both types of metadata. The EXIF capture time embedded in images was unreliable; in some cases, the recorded time was consistent with the caption details and scene (such as dusk), while other cases were clearly modified during editing and distribution. Photographer credit, meticulously recorded for the major photo agencies, was absent for some locations and sources, particularly those from China.

Of the thousands of photographs examined here, only the 35% provided by the AP and Getty included basic capture metadata about camera settings. The caption field was the most useful as its semi-structured text could be disassembled into multiple metadata fields, although with careful data validation. Data about focusing distance was needed to examine "safe distancing" from subjects during COVID-19 but such information is not available in standard EXIF metadata. (Even when retrieved from proprietary metadata during my tests, it proved to be unreliable.) Standards and technologies change rapidly as well, complicating data analysis. For example, the AP had used Canon EOS camera equipment for visual journalism for many years. During the pandemic it announced a worldwide transition to Sony products in 2020, a change with potential implications for journalistic practice, visual results, and available metadata.

These examples indicate that while visual dataset analysis presents useful opportunities for researchers, it is challenging to construct them reliably in current contexts. Given that phone cameras already use operationally opaque "imaging pipeline" software, it will be even more difficult to understand the context and authenticity of an image and take full advantage of the computational capabilities.

New ways of photographing need to be paralleled with new ways of researching, and new opportunities for research. Structured, validated, and annotated visual datasets are useful for other longitudinal and comparative research as well, including for example images related to climate-related change. Because computational photography involves sensors and algorithmic techniques, a photograph made by such methods can include information about context and a preliminary analysis of content; such a "photograph" is more of a situational dataset than a visual image of a single moment. Visual research often depends on combining data from multiple datasets such as these, but current metadata is unreliable and spotty, and details about emerging computational practices are not accessible. Access to recent capture and analysis techniques remains to be standardized.

Visual researchers would benefit from a robust capture and analytical toolkit based on computational photography. The development of visual tools appropriate for research is currently fragmented and often proprietary. Software developers have combined sensor data with images in recent "augmented reality" capture apps such as Theodolite (Hunter Research

and Technology) that not only display metadata but also record it with the image files for further analysis. Basic image statistics are available as specialized functions in Adobe Photoshop, but these are limited and clumsy to automate. Adobe Lightroom's library module can support the cataloging and image browsing functions necessary for visual research projects (Kilker, 2016), but accessing its internal database and other features requires often-experimental third-party plugin software that may not be reliable or updated. Trophy, an open-source visual archival tool, is optimized for annotation and organization for historical documents but does not support scripted analysis. The "R" project for statistical computing has specialized packages for visual output, but no libraries for visual analysis. ImageJ, and the updated FIJI version popular in the life sciences, have extensive analytical libraries and robust community participation (Schneider et al., 2012) but outdated user experiences.

An ideal visual analysis toolkit would combine the research features I employed on this project: Scraping and ingestion (using Google Sheets and PhotoMechanic), database (Google Sheets), human and automated analysis (OpenRefine and image classification via low- and no-code software such as Retrobatch), and interactive reporting and visualization. Accessibility of the research software for exploratory research is important: One model for grouping analysis features is Voyant, a collection of reading and analysis tools for digital texts (Rockwell, Sinclair, 2016). An ideal visual analysis package would exchange data with Phil Harvey's ExifTool, computational image analysis models such as samples hosted on the Allen Institute for AI's Vision Explorer, and facilitate both automated, guided, and semi-manual content analytic coding. Such features already exist in visual workflow systems used in journalism; the AP, for example, already "automate[s] as many noncreative, rote editorial tasks as possible to free our reporters to work on more meaningful journalism. As part of that effort, we introduced new technologies for text summarization, image recognition, real-time video transcription and the verification of user-generated content" (Associated Press, 2018).

Visual researchers produce not only research findings but can shape the technologies and techniques we use. Moving beyond current methodologies to incorporate new visual approaches is necessary yet daunting. Knowing when to explore new approaches is challenging, especially when researchers and fields are under productivity and existential stress, and results are uncertain. A natural concern is that the more attention researchers devote to technologies and methods, the less we can devote to research topics.

The example and challenges explored here suggest that visual researchers would benefit from closely following and engaging with visual technology development. Visual researchers need to closely observe trends in visual technologies in terms of research implications, or, better yet, participate in their design, as in the C2PA coalition. More than ten years ago, computer vision researchers collaborated on a modular "Experimental Platform

for Computational Photography" (Adams *et al.*, 2010) project that influenced features now available in our phone cameras. A similar strategic collaboration among visual scholars could lead to tools that combine visual metadata, traditional content analysis annotations, and emerging computational features, along with "hyper-photography" interactive presentation that would facilitate exploratory analysis and presentation of both research workflows and results.

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