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**Opinion**

# Data Science for Virtual Tourism Using Cutting-Edge Visualizations: Information Geometry and Conformal Mapping

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We highlight the advantages of virtual tourism and the use of data science to improve existing television and internet-based experiences with new technologies. Information geometry and conformal mappings can improve audiovisual experiences based on drone recordings. The data collection, assimilation, and transformation requirements for a seamless and user-friendly service are discussed along with the precautions to ensure that this technology is used appropriately to protect human safety and the environment.

The impact of COVID-19 will be felt for a long time and in a great many aspects of human society. This article, while acknowledging the serious loss of human life from COVID-19, aims to look further ahead to what potential new technologies we can put in place to improve human life in the future. We do this by investigating the potential of virtual tourism as a way of improving the quality of life while reducing the risks associated with wide-scale travel, whether those are personal, medical, environmental, or financial.

The air travel and hospitality industries all around the world have been severely affected in 2020 due to the spread of the novel coronavirus SARS-CoV-2, or COVID-19[1,2], which has resulted in several tourist places being temporarily closed.[3–5] Cruise-ship tours have been canceled throughout the summer of 2020 as a safety measure against COVID-19.[6] This impacts the millions of people who are employed in tourism and related jobs who contribute about USD 9 trillion per year to the global economy through the tourism and travel industry.

In this article, we propose the development of a new set of data science technologies which can help to strengthen and revive the virtual tourism industry as well as potentially improve the industry's carbon footprint. The idea is to jointly use three-dimensional (3D) or two-dimensional (2D) visualizations of tourist places alongside live video streaming from drones and other methods, called live-streaming with actual proportionality of objects (LAPO) technology. This new technology potentially will enable users to have an enriched experience beyond that from video on the Internet and television (by making the visuals proportionate to the various objects at the actual location, though the visualizations will need to be preprepared before combining them with live video streaming.). Moreover, the development of these technologies can help to transition existing employees in the tourism and travel industry to new tech-savvy industry and will also create new employment opportunities.

Depending upon the tourist spot, touring through LAPO might provide a better user experience than a real visit. In some cases, for example, visiting the Arctic, the virtual experience will be far safer than the real one, while still being entertaining and educational.

## Advantages
The advantages of live streaming associated virtual tourism include:

1. Cost-effective: It would be cheaper for a virtual tourist than for a physical tourist.
2. Health Safety: Virtual tourism can be done while the tourist is unable to travel because of the risks of transmitting and acquiring infections and viruses.
3. Saves time: The time taken to participate in virtual tourism will be much shorter than real, traditional tourism, allowing more virtual tours to be taken.
4. Physical-disability-friendly and senior-friendly: Tourists with limitations on their ability to travel can still experience what it is like to visit new locations.
5. Virtual tourism is safer and more secure: The virtual tourist does not have to worry about jetlag, crowds, muggings, diseases, and other discomforts.
6. No special equipment required for virtual touring: A standard home computer with a graphics card and Internet access will be all that any virtual tourist will need to enjoy a virtual trip.
7. New employment opportunities: Virtual tourism creates new employment opportunities for virtual tour guides, interpreters, drone pilots, videographers, and photographers, as well as those building the new equipment for virtual tourism.
8. Development of new technologies: Development of new technologies would include 3D live-stream-generating drones with multiple-drone systems capable of maintaining the conformal properties of images and videos.
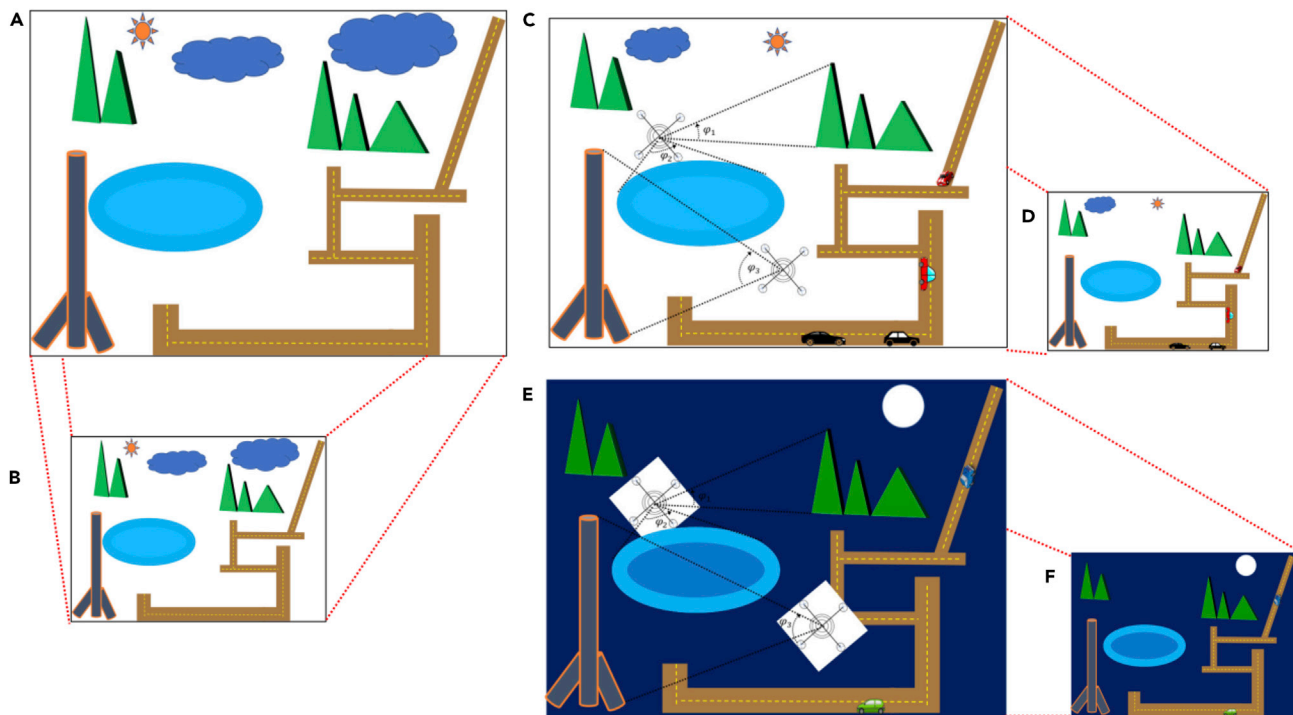
**Figure 1. Demonstration of Pre-captured Image and Live Streaming of a Hypothetical Tourist Location**
(A–F) (A) Tourist location, (B) pre-captured image of the location in (A), (C) live streaming of the tourist location in (A) during a particular day, (D) live-streamed image of the tourist location of (C) during the day, (E) live streaming of the tourist location in (A) during a particular night, and (F) live-streamed image of the tourist location of (D) during the night.

The development of smooth virtual tourism experiences will take time and input from users. As a first step, a trial study could be conducted among a diverse sample of tourists who have visited a tourist location within the last year to compare it with the virtual tourism experience using LAPO. An experience score of the two types of tourisms by the same group or different groups can be constructed to capture the degree of satisfaction as well as identify areas of improvement for both.

**Information Geometry and Conformal Mapping**
In this section we discuss some of the data science techniques which can be used to implement virtual tourism through improving the user experience of 3D visualizations.

The ideas of applications presented here or in Figures 1 and 2 are original. When a photo or video is shot (using drones or otherwise), then the visual effect of the distances between two or more objects in the photo or video needs to be exactly the same as that of the real image experienced

by the physical viewer's eyes. The angles between those objects and the angles within the same object, also as seen by a viewer, need to be preserved as well. These two sets of data need to be consistent such that the respective ratios of the actuality seen by a viewer are maintained in the visual effects experienced by the virtual tourist through photos or videos. Since photos are 2D objects, all the angles between objects cannot be preserved, and hence the virtual viewer doesn't experience the scene in the same way as the physical viewer. The distance between objects is handled through the concept of geodesic distances whereas the angles concept is related to conformal mapping.

**Fisher-Rao Metrics**
The Fisher-Rao metric can be used to compare two shapes within the space of probability distributions. This is also helpful for transformations of the data used to convert between 2D and 3D mappings. The 2D and 3D images of the tourist locations' various objects and shapes need to be embedded into the space of probability distributions, and then we measure distances on Riemannian manifolds. The

Rao's distance on Fisher-Rao metric on a standard setup can be defined as

$$d_s = \iint E\left[\left(\frac{\partial \log p}{\partial \theta_i}\right)\left(\frac{\partial \log p}{\partial \theta_j}\right)\right]d\theta_i d\theta_j,$$

here $p(x, \theta)$ is the probability distribution with a parameter $\theta$ which is continuous. See Rao, 2009[7] for more information on mathematical setting and further references on such metrics.

**Conformal Mapping**
Suppose the points of actual geometric measurements of a tourist location are plotted on some 3D graph. Shrinking the graph proportionately in all the directions will not change the conformal mapping properties of the original graph and the shrunken graph (because the proportionate distances between various objects and angles within and between objects would not have changed). However, if we roll the 3D graph a bit as shown in Figure 2, then the objects would lose the conformal mapping properties. When drones travel over the sky to capture live streams, their data collection and processing algorithms have to be built to
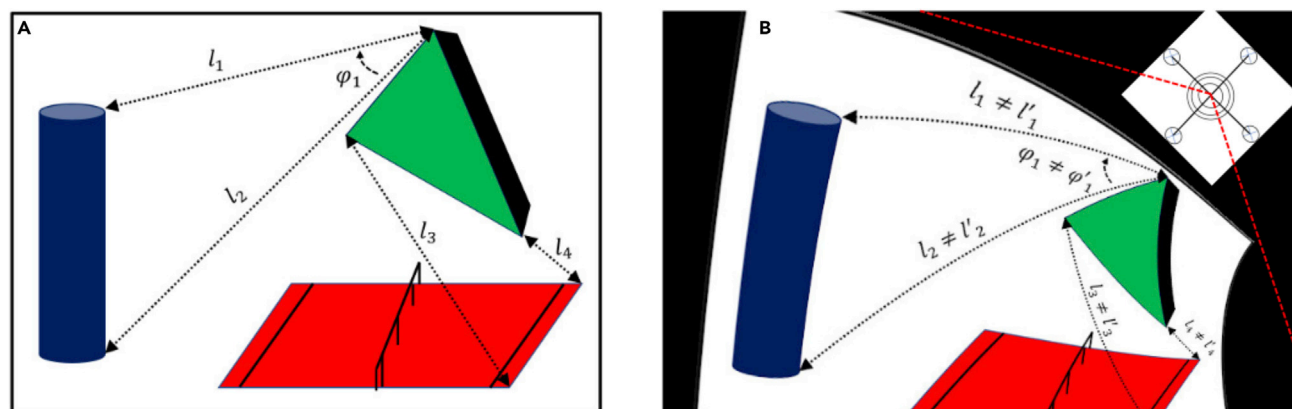
**Figure 2. Loss of Conformality Due to Improper Live Stream by a Drone**

(A and B) (A) Regular visual of a hypothetical tourist location. Distances $l_1, l_2, l_3,$ and $l_4$ are distances between various points as indicated in the picture, and $\varphi_1$ is the angle between two imaginary rays or curves touching from the top of the pyramid-shaped object to the top and the base of the cylinder-shaped object. (B) shows a live-streamed vision provided by a drone from a certain location in the space of the tourist location. Various distances and angles were distorted in (B) such that $l_1 \neq l'_1, l_2 \neq l'_2, l_3 \neq l'_3, l_4 \neq l'_4,$ and $\varphi_1 \neq \varphi'_1$.

preserve conformal mapping and properties of certain metrics so that the visuals maintain the actual distances between objects, including heights and depths.

Now let us consider two sets $A$ and $V$ within a normal Euclidean space. Let $A$ consist of all the points of the actual visual frame of a tourist spot as in Figure 1A and $V$ be the set of all points of a live-stream frame of the same tourist location. A function $f : V \rightarrow A$ is called a conformal mapping at every point in $V$ if the angles are preserved between directed curves drawn at each point of $V$ and orientation is also preserved as that of the set $A$. In general, if $\mathcal{C}$ is a complex plane, then a function $g : \mathcal{C} \rightarrow \mathcal{C}$ is conformal if, and only if, there exist two complex numbers $c_1$ and $c_2$ such that $g(z) = c_1 z + c_2$. For technicalities of conformal mapping and angle-preserving techniques with various functional transformations of the data. See Krantz[8] and Churchill and Brown.[9] For an ancient resource on shapes and forms, refer to Thompson[10], which provides interesting thoughts philosophically related to the current article.

## Data Science Connection

The video and images generated from various points of tourist locations will produce a huge amount of information about the contours, curves, angles between curves, and relative positions of objects in those locations. Novel algorithms will need to be able to perform data transformations on the fly while preserving the key aspects of information mapping and conformal geometry mentioned above. The visual data collected and processed

data generated would be massively high in volume and would need a huge amount of storage space, quality control, and data management by the virtual tourism industry. Such large volumes of data require careful handling at all stages of the processing chain to ensure the best quality experience for the virtual tourist. In addition, further information on the tourist locations, guides and their expertise, languages, gadgets details, etc., need to be stored and handled by the data scientists. Financial and commercial data emerging from the virtual tourism industry will be very challenging too, and we anticipate the investments in this industry could emerge on par with other hospitality and tourism industries.

## Precautions and Warnings

It's important to remember that any new technology or industry can have unforeseen consequences. We must keep in mind the potential abuses of virtual tourism as well as the advantages.

For example, drones can potentially damage the environment, either by disrupting animals and plants, or by harming delicate ecological structures. Privacy and security are also important factors, as networks of drones could be hacked to spy on private individuals or used for military or terrorist purposes. A positive balance should be maintained between the usage of virtual tourism as entertainment without harming society, which will require guidelines and codes of practice developed in collaboration with the people living in the tourist regions.

We also note that the pleasure of travel and other advantages associated with visiting favorite tourist spots cannot be fully compensated with an LAPO.

## Conclusions

Regardless of how the society changes in the future as a result of global pandemics or climate change, it will be valuable for the tourism industry to start exploring and adapting to new technologies so that a parallel market of virtual tourism gets developed. This will help millions of people depending on travel and tourism-related jobs as well as improve the quality of life for virtual tourists. The virtual tourism industry combined with LAPO could grow rapidly across the world just like the hospitality industry.

These ideas are not only helpful in the absence of any pandemics but also could help reduce the damage caused by thousands of tourists visiting tourist sites, both in terms of reducing $CO_2$ emissions and also the wear and tear due to physical contact with ancient sites. Such reductions in actual tourism could have a positive effect on climate change. The new data science methods described here could help develop the technologies required to make virtual tourism a common part of everyday experience, similar to movie theaters, television, or mobile phones.

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**Arni S.R. Srinivasa Rao** was born and raised in India until he obtained his PhD. Until 2012, he held a permanent faculty position at Indian Statistical Institute, Kolkata. He conducted research and/or taught at several institutions, such as the Indian Institute of Science, University of Oxford, and the University of Guelph. He taught courses such as real analysis, complex analysis, differential equations, mathematical biology, demography, and stochastic processes. His works on blockchain technology with hybrid models, epidemiological policies, and Chicken Walk Models are widely discussed for their practical value. Rao's other noted contributions include his fundamental theorem in stationary population models (Rao-Carey Theorem), Partition Theorem in Populations, and AI Model for COVID-19 Identification.

**Steven G. Krantz** received his PhD from Princeton University in 1974. He has taught at UCLA, Princeton University, Penn State, and Washington University in St. Louis. He was chair of the latter department for five years. He has written more than 135 books and more than 270 scholarly papers. He is the founding editor of the *Journal of Geometric Analysis* and the creator, founder, and editor of the new journal *Complex Analysis and its Synergies*. Krantz has won the Chauvenet Prize, the Beckenbach Book Award, and the Kemper Prize. He was recently named to the Sequoia High School Hall of Fame. He is an AMS Fellow.