Art and Color in the Context of CFD: Towards a Better Engineering Design

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Typically the words 'art' and 'CFD' tend to appear in the same sentence only as either 'the art of using CFD' or, particularly when conferences and meetings are announced, as 'state-of-the-art' CFD. Unquestionably in the latter context the art of good modeling is synonymous for representing reality as close as possible. Certainly this is true for both, numerical and experimental modeling. Color on the other hand is more fundamentally related with both, art and CFD. Indeed in the 1980s CFD was often nicknamed as 'colored fluid dynamics' as color was largely absent from experimental techniques at the time.

Over the years the author became aware that a fair number of CFD specialists have a distinct liking for the arts, particularly for abstract, non-representational art by artists like Wassily Kandinsky and Paul Klee. Therefore the author analysed the common features between these very different metiers and came to the conclusion that CFD and art, particularly abstract art, are intrinsically linked, not only by colour, but also by shape [1]. Other scientists have also asked themselves why one likes certain types of art or music [2]. Since the times of Leonardo da Vinci science and art have diverged. John D. Barrow writes "as science became more successful to explain the seen by the unseen laws of Nature, so art became increasingly, metaphorical, and divorced from realistic representation". Yet with the immense advance of CFD software art and science seem closer than ever of merging again.

So how are art and CFD connected? What are the common features? And why have many of us an intense liking of colorful, abstract art? As the readership well knows the discretization process involves dividing the computational domain into small cells which, for a 2D problem, involve the basic shapes of triangles, squares and rectangles. Not only are triangles and squares members of the group of "primary" shapes, but also the process of dividing the domain into regular, smaller areas is not unlike that of generating a stained glass window. Stained glass windows, particularly those colorful ones of the Victorian and Edwardian era, tend to consist predominantly of squares and rectangles, but also of triangles and circles. Many were strictly non-representational

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and solely pattern-based, but many became softer, in a way more "fluid", when combined with images of plants or birds. About the shapes Kandinsky writes in 'Űber das Geistige in der Kunst' ('Concerning the Spiritual in Art') in 1912 ''purely abstract entities, existing in subjection to their influence and effect, are a square, a circle, a triangle, a thromboid, a trapezoid, and the countless other forms which become ever more complicated and have no mathematical name. All these forms are citizens of equal rights in the realm of the abstract'' [3]. Indeed, some artists restricted themselves by using only squares and rectangles as Piet Mondrian did in his paintings (typically using the primary colors yellow, red and blue, and black and white). In particular the glass panels from Frank Lloyd Wright remind the numerical flow modeler of the discretization procedure due to their underlying mathematical, engineering design method [4]. As these basic, fundamental shapes form the basis of many engineering structures, they therefore regularly feature as base configurations in CFD simulations.

In design, as the art form, e.g. architecture or interior design, color is important in a whole range of aspects, be it in the context of light, colour contrast, the trueness of colors, as well as their effects on shape, space and material, or as means of expressing with color. The value of colour in CFD, particularly in post-processing, has been demonstrated by many scientists. In the complementary descriptions of the works of a current group exhibition entitled Colour [5] it states that "in scientific imaging, color is used simply to differentiate one subset of data from another." While this statement holds on a fundamental level, one cannot ignore the impact of the perception of color. It is widely accepted that the use of color can add three-dimensionality to intrinsically two-dimensional information [6]. Indeed when cleverly used color is capable to add a "fourth" dimension, too. By overlaying solid color contours of a flow variable in one plane with colored contours, streamlines or particle paths in another the post-processing image can be read in a number of ways, hence adding dimensionality. Some nice examples for this may be found in[7,8]. And not only does sophisticated post-processing aid the understanding of fluid flow, but these CFD presentations do become, to some degree, art in their own right. It may be these commonalities why many CFD modelers have a great fondness of art, and in particular abstract art. While Barrow [2] draws interesting links from how we experience art to evolution, the environment and the Universe, us modelers may want to judge ourselves where the art is in CFD.

However, just as art will never be reality, only an interpretation of it, a computer model will never be exactly true, albeit being very close. But despite small discrepancies in the results obtained from a CFD model remaining, be they the result of limitations of the underlying models, inaccuracies invoked by the discretization technique or the applied boundary conditions, CFD is a fundamental, powerful technique to lead ultimately to a better engineering design, be that of an aircraft wing, a turbomachinery blade or a stent to keep a blood vessel open. And with our continued strive for improving the modeling accuracy in CFD the gap to reality steadily narrows.

With this in mind I would like to welcome you to another interesting volume of CFD Letters. The topics range from a validated study on the aerodynamics of the Ahmed body presented by W. Meile et al. to the application of an inverse CFD model involving heat transfer to estimate the radius ratio for a fin by Ranjan Das. Yang Duo-Xing and Zhang De-liang introduce an improved second order CE/SE method for simulating multiphase flows in porous media, while the authors Brajesh Tripathi and Sandipan GhoshMoulic assess the effectiveness of an air-conditioning system by evaluating inclined ceiling diffusers on buoyancy and airflow patterns. In the paper by Pavan Sharma et al. RANS and LES is used to predict the short and long term distribution and mixing of hydrogen in a large enclosure. Enjoy the issue!

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