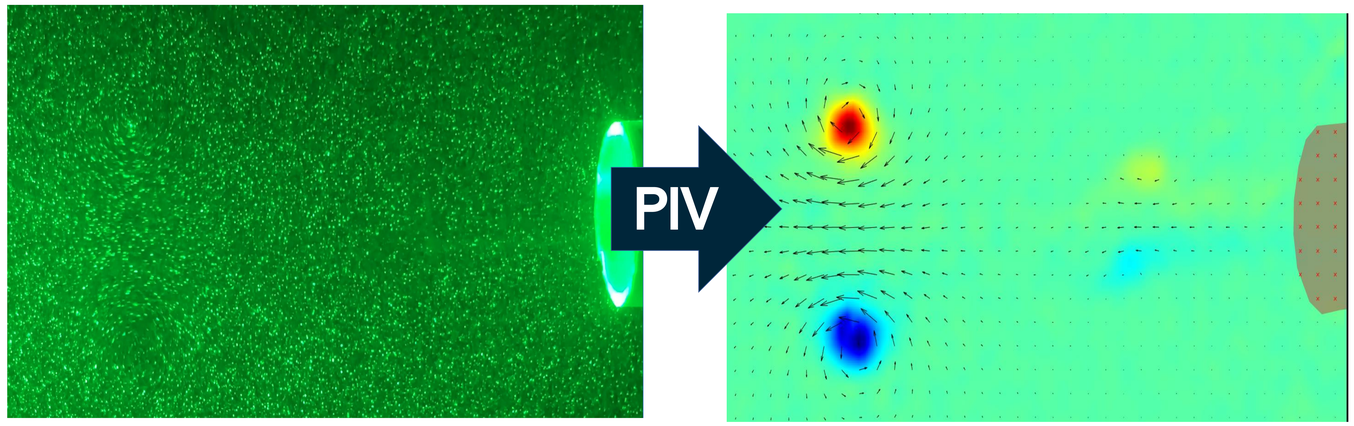
Development of a Particle Image Velocimetry (PIV) Learning Tool: *Learnpiv.org*

What is PIV?

Particle Image Velocimetry (PIV) is an optical, experimental technique which uses lasers and digital cameras to noninvasively measure the velocity of a flow field. Imaging light scattering particles moving in the flow and then analyzing successive images using complex algorithms results in a PIV velocity vector field. **Collecting useful images and properly applying PIV algorithms requires fundamental knowledge of digital imaging and PIV. This requirement inspired our development of a web-based tool for novice PIV users called *Learnpiv.org*.**



Development

Stage 1: Finding a Framework

We chose to develop *Learnpiv.org* as a Django web framework because the synthetic image generator is written in the Python coding language. The synthetic image generator, created in Spyder, requires imported libraries such as matplotlib and numpy which are essential for PIV experimentation. In our Django application, we created a virtual environment where we stored these installed libraries, enabling code from the synthetic image generator to run outside of Spyder's integrated development environment. The next step was to find a host.

Stage 2: Finding a Host

We chose Heroku to host our web application as opposed to other hosting services such as PythonAnywhere, AWS or DigitalOcean. Monitoring learnpiv.org through Heroku allows easy updates to the web application without a temporary server shutdown. Further, Heroku provides a free tier subscription with over 500 MB of database storage through a Hobby PostgreSQL database which is more than enough storage for our educational purposes.

Experimentation

For users to learn the impact of imaging and processing parameters in PIV, we provide single variable and multiple variable experimentation. Specifically, users can change image and processing variables which results in different synthetic image generation, and thus different images.

Single Variable

We created the Single Variable experimentation page to help users understand the influence of individual image and processing parameters on PIV results. When the Run Simulations button for a single variable is clicked, a list of images and errors corresponding to changes in that variable are presented to the screen (Figure 1). This allows users to visually and quantitatively assess each variable's influence on PIV results.

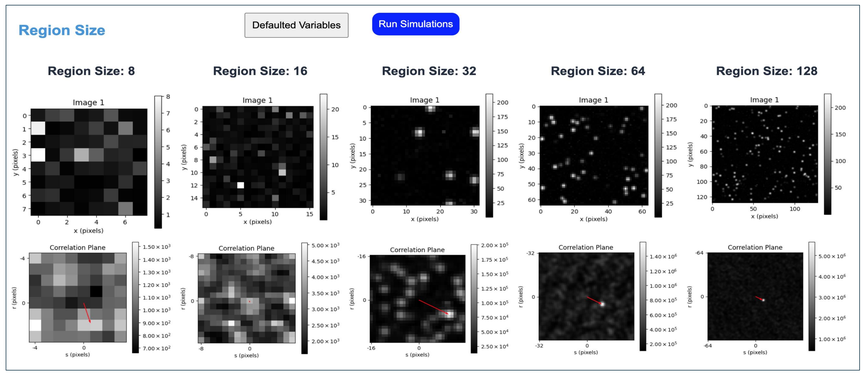


Figure 1: Images and correlation planes after running a simulation for the Region Size variable, demonstrating an ideal region size for the fixed displacement of 32 pixels.

Multiple Variables

The purpose of the Experiment with Multiple Variables page is to give users the freedom to input and alter multiple image and processing variables. This page can be intimidating for beginners, so we provided defaulted values for each variable. In addition, to prevent unreasonable variable inputs and reduce computation time, we set boundaries for each variable. Figure 2 demonstrates the output after a user clicks on Run Simulations. Further, users who create an account can give these experiment results a name and save them for later observation.

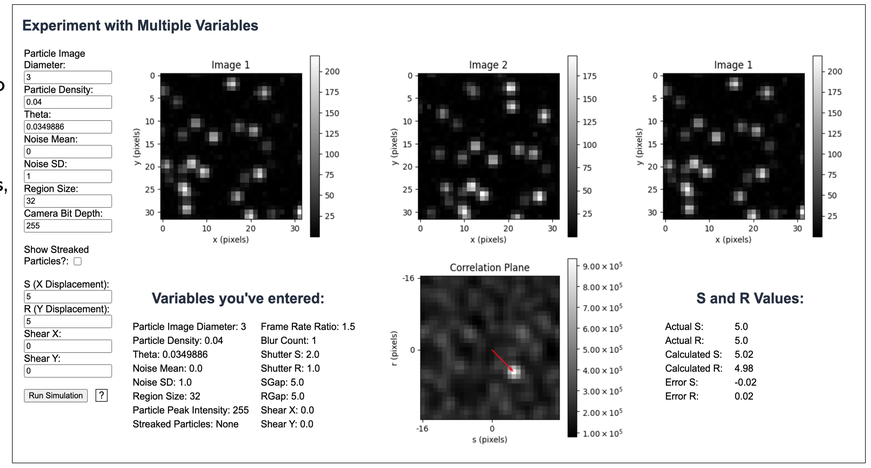


Figure 2: Multiple Variable page after running a simulation. Displays Image 1, Image 2, animation, entered variables, correlation plane, and S and R values.

Content

To help users understand PIV imaging and processing parameters, *Learnpiv.org* provides pages of PIV basics and variable input information. This learning content is structured to guide beginners in a step-by-step fashion while allowing advanced users to navigate directly to points of interest. We separated this learning content into three sections (Figure 3), starting with the How PIV Works page (Figure 4).

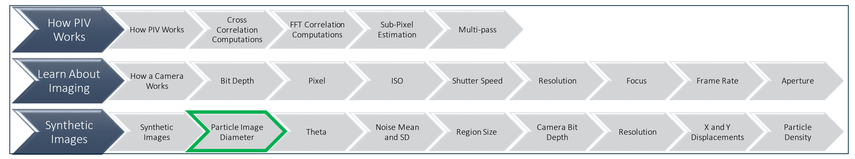


Figure 3: Learnpiv.org learning content flowchart.

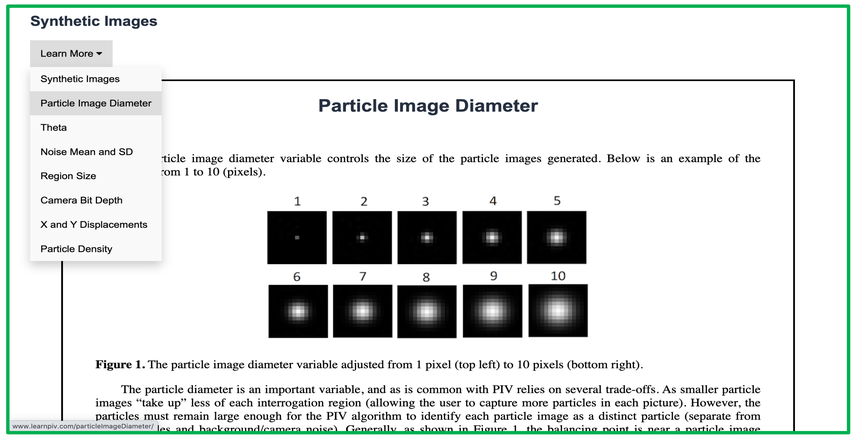


Figure 4: Demonstration of the learning content Particle Image Diameter page.

Conclusion

The purpose of *Learnpiv.org* is to educate novice PIV learners about the fundamentals of PIV imaging and processing. I believe we succeed in this goal by providing free, easily accessible PIV content and experimentation. Further improvements on *Learnpiv.org* originate from our feedback page. In the feedback page, users can provide suggestions to help us understand which aspects of our website need to be changed for providing a faster, easier learning experience.

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Research Funding: Office of Naval Research (ONR) Navy and Marine Corps Science, Technology, Engineering & Mathematics (STEM)Education and Workforce Program Grant # N00014-18-1-2770

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