Fundamentals, materials, and machine learning of polymer electrolyte membrane fuel cell technology by Yun Want et al.

Other than some very basic and superficial reading here and there, I did not know much about fuel cells. I am currently learning. I cannot say that I am surprised to see ML applications on fuel cells, but I did not have any concrete examples.

According to the article, the two major barriers to the worldwide development of fuel cells are durability and cost. So, it is safe to assume, that these are also the areas ML can contribute tremendously.

One area that ML can be utilized is membrane material development. As far as I can tell the membrane is the most important part of a fuel cell. The authors say that there are extensive studies in different areas for membrane materials and ML can b used to analyze these experiment data of membrane cells. But I must say that I do not have a current method in my mind for this job.

Another task they point out is design. According to the authors ML can be applied to catalyst layer, microporous and gas diffusion layers. They emphasize “physics-informed” deep learning, but I have no knowledge of them.

They also propose application of ML on bipolar plates and coating materials. Additionally, they say, again, physics-informed deep learning on gas diffusion layers.

There is also another study mentioned in this one which proposed to analyze two-phase flow images and results for general fluid problems. I do not have much experience in this area but considering the success of neural networks on images. This area might be ripe for some innovation.

They also claim that fundamental analysis of the time constraints to explain fuel cell signals observed in practice and reduce noise. Therefore, develop ML models to predict dynamic behaviors and optimize control strategy. That sounds interesting, but I do not know how much about control in fuel cells. But the prediction might become useful.

Once again, physics-informed deep learning. This time for ice formation and understanding environmental operating conditions for fuel cells.

Authors write “We can expect that deep learning, such as physics-informed deep learning will become the most important path to AI”. I would say that is definitely a bold statement. Although it is said that neural networks try to mimic the human brain loosely, there is an emphasis on “loosely”. As far as we know, there is no such mechanisms in human brain, which is my major criticism. But as far as I know, our brain has certain mechanisms to understand the physics of the world, so I can understand where they are coming from.

They also say that ML is capable of establishing the relationship between inputs and output performance through proper training of existing data. This might be really interesting, in my opinion. Instead of running experiments which are costly, a hypothetical fuel cell or fuel cell stack experiment can be analyzed with a pure ML approach.

And they also point out to the surrogate modeling to replace complex physical models. I have some knowledge of the concept but have limited experience. Lastly, they point out ML applications to discover new material properties and develop next generation materials.