Report

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My work throughout this project has touched several areas, such as patent research, creative design, or safety analysis; but most notably in has focused on academic research, and team coordination and organization.

This project was my idea, and as such I had to research into the conceptual design, the implementation, and the feasibility of the constructions. I was interested in exploiting Synthetic Biology to create a semblance of interface between *in vivo*, and *in silico* systems. That idea got me on track towards current telecommunications and the platform on which they are based: electromagnetic waves. Seeing as how using this platform enables a broad range of applications, I immediately likened it to the Wi-Fi Alliance's platform [1]. However, having found extremely poor information on proteins capable of sensing the radio spectrum, and knowing of the diversity of proteins that sense visible spectrum, I settled on using this last spectrum. The other take on the system is the use of non-chemical messengers to achieve inter-celular communication, however I personally feel this analogous to non-physical-contact communications, i.e. wireless. An ambitious perspective on the project was to develop a way to tune proteins to certain wavelengths. While a most interesting option, it proved too complex for our current scope as undergraduates with limited funding.

In the early stages of project definition, I was actively researching diverse topics, such as Bioluminescence Resonance Energy Transfer [2], the luciferin Chirality Inversion and recycling pathway [3], and Quantum Yield [4] to name a few. The BRET was an interesting option to generate new color code channels in the system. That way we could get more information bits in our bacteria channel, or make more binary channels in our bacteria. Eventually we settled on three spectra evenly spaced: red, green and blue. For our red emitter, I found the required information to prove that Photinus pyralis luciferase was an alternative. Likewise, I found the information for our red receptor, the EnvZ-OmpR two-component system [5]. Finally, I investigated the Quantum Yield in an effort to determine if it could be an issue on our system. I determined that with a sufficiently high number of exitation events and modeled as a binomial chain, even a low Quantum Yield would not affect dramatically the system.

Once the project was under way, I assumed the role of organizing the modeling section of the team. It was I who decided on the modular aspect of the model [6], the multi-level approach at results [7], and the diversification of platforms (i.e. Simbiology, Kappa, and Neural-Network). I decided that compartmentalizing the system would yield a more efficient model because it simplified common grounds and interfaces (i.e. PopS, Photons). Moreover, it helps us to define our project as a modular one. Indeed, since the original idea was an interface, the expected model should be of an interface. As for the multi-level approach at results, sometime in the course of the summer we began considering the possibility that we might not get any results whatsoever from the wetlab section. Therefore, I began thinking how to escape this conundrum. Taking input from my teammates, I rearranged our modeling ideas into modular levels. The first and most simple was once where we could complete a primary model based solely on literature data. Should we obtain some experimental data, we could replace some theoretical models with these characterizations to have the second level model. If we finished characterizations, we could replace the entire theoretical model with real data and thus have a third level model. These three levels were to serve as fail-backs for the multiple scenarios of experimental data. This proved to be a very good idea, since we lost a lot of time waiting for data that would never unfortunately arrive.

I took upon myself several miscellaneous endeavors, such as the development of our Wiki [8], the refinement of our logo [9], and the Safety and Security issues [10], not to mention diving into the Patents and Trademark's Office electronic query system to search the status of our project's name [11], or collaborating in the soldering of our LED array [12]. The development of our Wiki came at a time where the rest of the team took their summer vacation. I stayed to work on the non-essential parts at that time, mainly the Wiki because I had some experience in HTML and Javascript. I got our Wiki up and running in time for the Edinburgh team to notice it. It was thus that our collaboration was born. As for our logo, we experimented with different designs, and eventually we settled on one. Having some experience in Photoshop, I decided to finish this particular design and rendered our current one. Likewise, knowing a bit of Flash, I made our introductory animation [13]. This animation was transmitted on local television when we were hosted on a morning show. As for the Patents and Trademarks, some teammates had voiced their concern that Wi-Fi was a trademarked name. I therefore decided to look closely at said issue. On the electronic query page for the US Patents and Trademarks Office, I found that while "Wi-Fi" was indeed a trademark by the Wi-Fi Alliance, the term we had been using was "WiFi", and it was listed as claimed but dead. We were therefore free to use it. On the LED array, it was clear we needed a device to irradiate our cultures on a time differential manner. Having some experience with electronic circuits and soldering, I helped in the construction of said array.

On a more theory-oriented research, I was actively looking for ways to measure our luminous output. While the model could easily generate photons, we needed a way to transform these into a more user-friendly dimension, such as watts/area, lumens, candelas, etc. Eventually we settled on using watts/area since this is easier to transform into and from photons (modeling results), as well as into and from luxes (experimental results). However, with no experimental data, we didn't get to exploit fully our research into the area.

In the modeling proper of our project, I learnt to use Simbiology, however I focused mainly on the Kappa implementation [14] as well as the Neural-Networks [15]. Being a large team, I distributed heads among the platforms, even though we all learnt Simbiology. Thus, there were 2 persons working in Simbiology and 2 in Kappa; eventually we would all work with the Neural Networks when our advisor could give us an introduction to them. However, due to overloading a teammate with the Human Practices as well as with Sponsors, I took his role in Kappa and Neural Networks.

Thus, I ended up the sole responsible for Kappa and Neural Networks. While we had tried to do some modeling in RuleBase.org, we had found it to be unreliable. When I found the command-line binaries, we began working with them. Similarly, many issues we had were solved when I joined the KappaUsers forum and troubleshooted them there. The point of using both Simbiology and Kappa was to compare and contrast the output for the two platforms, as well as to optimize computing-time. For Simbiology, we tried using the stochastic solver, however our computer equipment was unable to run it well. Therefore, we decided to use Kappa as our stochastic model, and Simbiology as the deterministic model. Once we had these relations between photons, PopS, and time, we could generate the associated transfer function for the interface, i.e. photons=f(PopS, Time) for an emitter, or PopS=f(photons, Time) for a receptor. However, I believe that the optimal characterization for an interface would have the input as the same nature as the output, in other words since we have a flux as input (PopS, Time), we should have a flux as output (photons, Time). This would require a 4D plot and a lot of simulations. Unfortunately, we don't have the time to finish said flux-to-flux modeling.

Finally, as the one who came up with the original idea and being a decent spokesperson, I've been involved in most presentations of the project to the local scientific community. I presented our work at the First National Workshop on Synthetic Biology in the city of Irapuato at the National Laboratory for Genomics and Biodiversity [16], as well as to some researchers at the Center for Genomic Sciences [17]. Likewise, I'll be giving the presentation at MIT along two other teammates.

References

1. First Presentation
2. BRET Presentation and Explanation
3. Luciferase How-To Presentation and Explanation
4. Quantum Yield Plotting
5. EnvZ-OmpR Presentation and Explanation
6. Modular aspect of the Model: Interfaces
7. Structured aspect of Model: Hierarchy
8. Wiki
9. Logo Overhaul
10. Safety Page
11. Trademark Query Page
12. LED array
13. Animation
14. Kappa Code
15. Neural Network Code
16. LANGEBIO Presentation
17. Collado Presentation