Communicating the Significance of your Thesis Persuasively

Example 1

One liner: My research aims to support the development of sustainable transportation systems by using system-level approaches to address complex environmental questions.

The transport sector accounts for almost a quarter of global greenhouse gas (GHG) emission, largely due to gasoline combustion of light-duty passenger vehicles, and mitigation pathways need to be implemented in light-duty fleet across the world to prevent more than 2°C global warming. But the common pathways rely on alternative solutions (e.g., lightweight vehicle design, biofuel, alternative vehicle powertrain) that shift the emissions from combustion to other phases of the vehicle life cycle, such as fuel or vehicle production. Therefore, there is a need to quantify the potential climate change mitigation pathways of light-duty fleet with comprehensive tools, and to assess their potential implications on our infrastructure needs (e.g., charging station, power plants, material supply chain), and on other environmental impacts, such as air quality.

As a PhD candidate at the University of Toronto, my research goal is to quantify the GHG emissions associated with light-duty vehicle fleets, estimate changes in emissions as a function of large-scale development of technological changes or policies, to outline mitigation pathways to prevent more than 2°C global warming, and to assess the implications of such pathways on our infrastructure, and on urban air quality. I use physic-based models at a vehicle level combined with micro- and macro-simulation models at a national level to achieve these goals.

Tackling climate change is not a one-country, one-sector or one-technology job. It will be the achievement of extensive system analysis, thorough planning and implementations. My research provides a comprehensive framework to shed light on some of the trade-offs that we will need to make to tackle this global issue.

Example 2

One-liner: I develop engineering tools to reverse blindness.

As we grow older, many of us will suffer from vision loss or even blindness, and once our vision is gone it cannot come back. This was the understanding that scientists had until very recently with the discovery of stem cells in the eye. The idea is that if we can isolate these retinal stem cells, we can then differentiate them into photoreceptors, rods and cones, necessary for vision, and transplant them back into the eye, effectively reversing the patient's blindness. However, trying to find these stem cells is like finding a needle in a haystack as they are very rare.

As an engineer, I am developing technologies to find and isolate these rare cells. With my tools, and many of our scientific collaborators, we aim to create therapies that can reverse blindness. These tools, called microfluidic devices, are devices which can take very small volumes of fluids such as blood, and move them through channels that are in the micron size range (one millionth of a meter). I design these devices to have features which can sort out the retinal stem cells from the other cells in the fluid sample.

My microfluidic approach sorts retinal stem cells in two ways: by their size, and by a chemical signature on the surface of the cell. Through my research, I have found that retinal stem cells are quite small compared to other cells, so I use a physical principle called deterministic lateral displacement which uses micron-sized pillars in my microfluidic channels to separate small cells from larger cells. I also have found chemical characteristics on the surface of retinal stem cells for which I can attach on small magnetic nanoparticles. I then use another microfluidic device which has magnets to pull cells with magnetic nanoparticles, i.e. the retinal stem cells, away from those that do not. The combination of these two microfluidic devices has helped us isolate pure populations of retinal stem cells.

Once my work is done, it will become a part of the full research effort to seek a future of personalized medicine for degenerative eye disease therapy. The idea is that we can take a cell sample from a patient's eye, sort out the retinal stem cells, differentiate the stem cells into the necessary light-sensitive cells, and then transplant the photoreceptors back into the eye.

Example 3

One liner: This research focuses on developing optimization tools and data-driven policies that empower and educate communities on how to save the lives of cardiac arrest victims.

Out-of-hospital cardiac arrest (OHCA) is associated with over 400,000 deaths annually in North American alone. Prompt treatment is crucial for survival after OHCA, because for each minute of delay, chance of survival decreases by up to 10%. Automated external defibrillators (AEDs) are medical devices that allow untrained bystanders to provide prompt treatment to improve chance of survival of OHCA victims. Current guidelines recommend placing AEDs in locations where OHCA has occurred frequently in the past, to promote rapid treatment by bystander. However, numerous barriers, including restrictive privacy legislation and limited number of OHCA databases prevent communities from obtaining historical OHCA data. Thus, it is challenging for communities to identify high-risk areas for AED placement to make optimal strategic decisions. Therefore, there is a need for assistive tools to allow communities to easily assess OHCA risk and identify the best locations to place AEDs.

To address this issue we plan to: 1) Develop an AED placement optimization tool, namely a mathematical model that identifies locations to maximize access to AEDs for use by bystanders, and to validate its usefulness in several cities around the world; 2) Develop an accurate OHCA simulation model based on predictors from commonly available data (such as neighbourhood demographics, etc.), as a means to identify high-risk areas without using historical OHCA data.

Only through the combination of medical and engineering practices are we able to develop and apply innovative mathematical models to improve bystander AED use and OHCA survival. These proposed models can support communities worldwide to make effective AED placement decisions that can help improve OHCA survival, and further develop international standards for AED placement. Our multidisciplinary approach exemplifies the innovations that can be made to help save lives around the world.