1. Problem definition (1 page maximum)
Describe an engineering problem that has a feasible technological solution. Please explain the purpose and function of the proposed technology, including which medical condition(s) it can be used to treat and/or diagnose. A brief description of the target performance requirements of the technology may be appropriate.

The problem we wanted to tackle was the language barrier in healthcare between patients and care providers. This is a problem in both developed countries that have an increasingly older population of non-native speaking immigrants, as well as developing countries where emergency medical relief brings together into one location an international team with limited understanding of the local language.

We spoke to health care providers in our own hospitals and clinics, and the general consensus was that interpretation services were expensive, time consuming to set up, cumbersome to use and inadequate in terms of accuracy. As such, we developed a tool to overcome these issues. Furthermore, we were frightened to discover through our research that in our own metropolitan city, which boasts diversity globally, patients who did not speak English received worse care, treatment, and had greater risks of death. A 2002 study of 1,800 people with active tuberculosis born outside of Canada and living in Ontario found an association between language discordance and increased risk of death. A 2004 study of three Toronto hospitals found that language discordance led to increased length of hospital stays, and a 1990 study of 22,448 women in Ontario suggested that women whose primary language was not English were less likely to receive some forms of cancer screening. Many such patients who present to a clinic have to undergo unnecessary diagnostic tests trying to figure out the problem. It may also lead to longer hospital stays. It is going to put a strain on the health-care system, especially in the developing world where rapid emergency treatment may be required, as was the case with the Ebola crisis.

We saw here an opportunity for technology to address the problem. Thanks to direction from a medical student team member, we felt that we could go beyond a phrasebook solution to tackle the problem. We developed a method that takes advantage of pre-existing medical best practice diagnostic tests/interview databases. With this, we can allow a health care provider to select the tests he/she hoped to perform, and through the use of sophisticated machine learning algorithms, we are able to translate the questions into a variety of languages. In short, we developed an app that can be downloaded to a smartphone or tablet, which acts as the primary point of triage for the patient. Not only are diagnostic tests translated to local languages, but we implemented the ability to respond and provide feedback to the medical staff.

We were met with the issue of limited access to rare, underserved languages. We overcame this after a meeting with the ZipCar founder, who recommended creating a platform to engage the multilingual medical community in participating in the translation and verification of tests in a style similar to DuoLingo's business model.

Our focus currently has been Emergency medicine, but we have the ability to expand to other specialties.

2. Impact in developing world (1 page maximum) Describe how your technical solution will benefit people in developing countries. Provide a brief description of any technology currently used to solve the defined problem. If there is an existing technology, please explain what advantages your proposed design will have (lower cost, increased portability, battery powered, more robust, etc.) over the existing solution.

We plan to dissolve the language barrier for doctors and patients, while providing valuable statistics that permit patient data management, or that can serve as a research tool. Our solution permits doctors to see more patients, reduce unnecessary tests, improve health outcomes, and provide emergency care rapidly without the assistance of an interpreter without compromising the privacy of the patient. The consequence of this is not just in the benefit of the patients, but the crisis relief teams as well. For example, interpreters, family members, and volunteers who would otherwise be exposed to non-sanitary environments are as well better protected by no longer having to be present physically, as a smart phone cannot get sick and it's death is less meaningful than a volunteer's.

Where in the developed world one has access to interpreters, this resource can be a luxury in times of crisis in the developing world. Often times, medical staff simply attempt to solve *a* problem for the patient without seeking any interpretation, as the resources are simply lacking. Although some areas have the benefit of having a few members on staff who are bilingual, this is not available to the majority of centres, and even when available the inability for such a staff member to be omnipresent creates an efficiency bottleneck in the flow of the health care service throughout the day. A 2006 study in a South African district hospital found that the language barrier interfered with working efficiently, caused significant ethical dilemmas, negatively influenced the attitudes of patients and staff towards each other, and caused cross-cultural misunderstandings. Yet this was the common practice.

Elsewhere patients are forced to rely on family members or friends. Technological solutions as well are inadequate. Google Translate is able to provide rudimentary translations, which are often ineffective in healthcare. Solutions such as Canopy App, Robert Thei medical phrases, SpeakToMe, and the plethora of other similar apps are simply digital phrasebooks with no interactivity. Apps such as Medlango (operating in Germany) simply connect doctors to already established interpretation firms via VoIP, and to the expense of the patient. The future is directed towards machine and speech-to-speech translation###

Our solution is more robust, not restricted to a limited database of phrases, interactive, and constantly growing. It is simply to use, and many folds less costly than paid interpretation services.

3. Required performance specifications (1 page maximum) List all relevant technical specifications that your technology must meet to effectively perform the function for which it was designed. These specifications must be justified with documented research and consideration of health care conditions in developing countries.

??? It's an app. Works offline.
The app requires a smartphone or tablet to run. Our choice here was based on accessibility. Research anecdotally or implicitly suggests that smart phones are the most widespread form technology in the developing world, and that health care providers travelling from developed countries almost always have access to a smart phone. A 2015 study suggests that even Medecins Sans Frontieres are considering disseminating medical information through mobile apps as opposed to traditional means for casting a wider more efficient net. Data on smartphone use in health care is limited but local studies from around the world suggest that smart phones in the health care environment are ubiquitous and almost completely available and accessible.

We have developed an iOS solution and are expanding to develop an Android solution as well. Studies are limited but largely anecdotal evidence suggests that iOS is the most prominently accessible mobile interface in health care.

We also anticipated that cell phone reception was limited, and opted to ensure the main features of the app are fully functional in offline form, as 100% cell coverage is limited in even the developed world. The team personally even failed to receive cell reception when in their workstation indoors, and we did not want a similar situation impeding with the care of the patient.
The community platform to build up the however relies on internet connection to help build up the language library.

4. Implementation of prototype (2 page maximum) Describe the functional prototype your Design Team designed and constructed to meet the required performance specifications outlined in the previous section. You should elaborate on the methods of construction and mode of operation of your prototype. You may include any drawings, schematics, figures, etc. in an appendix that will not count as part of your page limit. Do not include text in the appendix that goes beyond brief descriptive captions.

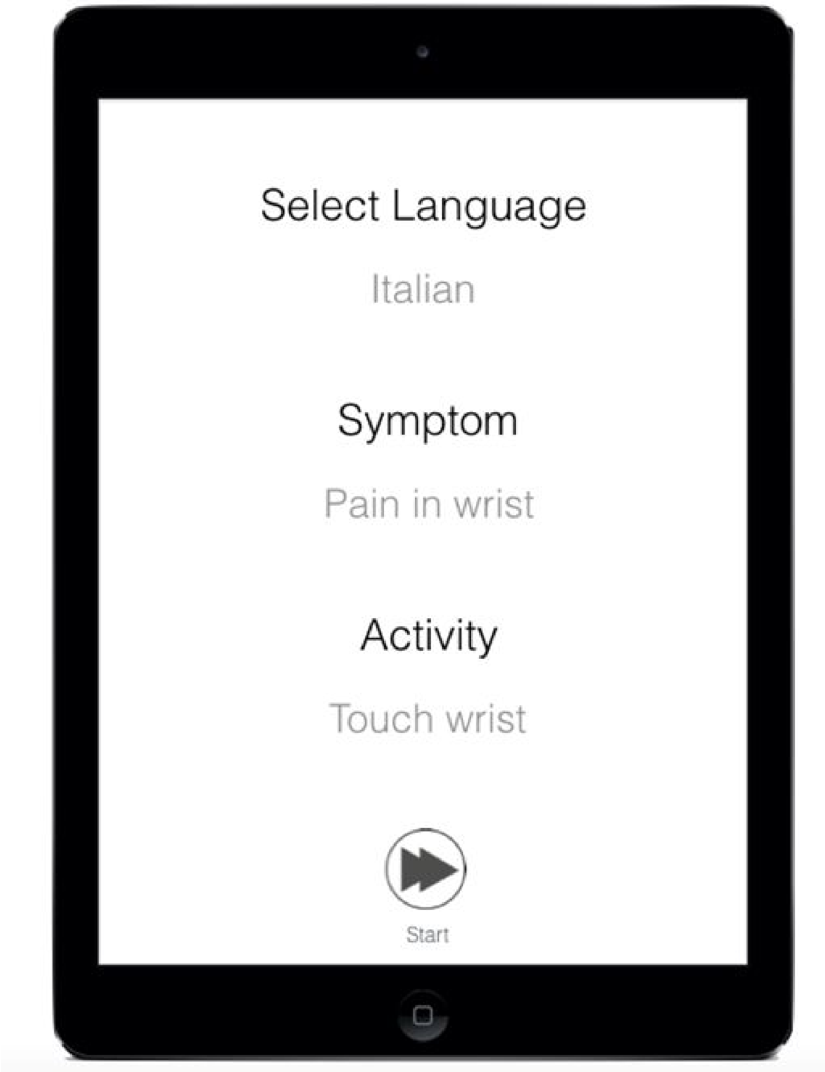
Translation
We begin with the medical diagnostic database that was selected for us by medical staff. This database was placed in a tree format. We had a program take snippets of text from branches this dataset and distribute each snippet to several multilingual experts authorized to provide translations and allowed to access a platform to do receive push notifications and respond. The responses were all analyzed against one another, and those with most commonalities were incorporated while the rest were sent out to other users for verification.

To attempt to achieve fluid language and cultural sensitivity, common case studies were prepared by MD consultants and pushed these multilingual experts were asked to enter greetings and common parlance questions. The results were again verified by distribution to other users speaking the same language, and compared against one another, initially digitally, and by performing simulations. By adding slight variances in the cases, we were able to develop a varied set of responses to simulate spontaneity. For example, a 65 year old female can be referred to by separate experts the equivalents of madam, grandmother, mother, dear etc.. or a 17 year old alternative as young miss, young lady, miss, honey, sweetheart, all of which the software was able to rank and pseudo-randomly introduce with some degree of machine learning for context. We targeted the two most in demand languages in our city- italian and hungarian, as the first languages, and we are continually expanding.

Diagnosis

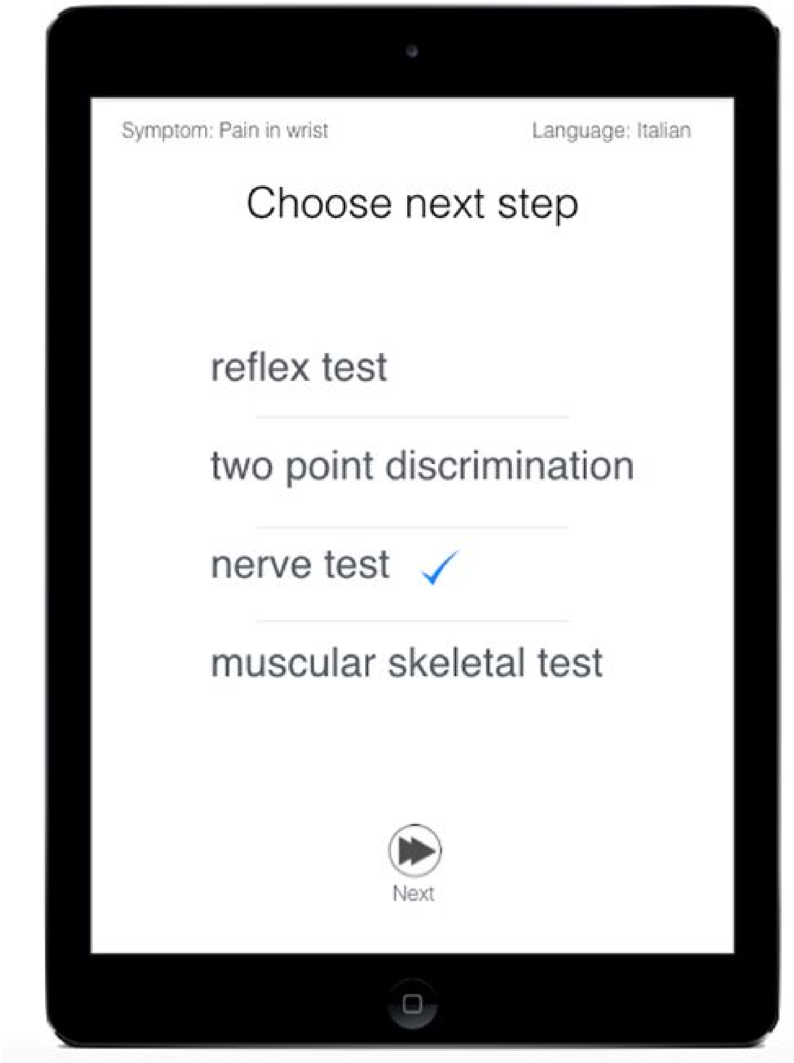
Once the language is selected, the patient is met with a history screen collecting relevant demographic data and medical history. Options are predetermined, and have one-to-one correlation between languages.

For the time being, we have focused on physical symptoms, though we are building our library for mental symptoms. If the patient is literate, they can enter the areas of their symptoms, or alternatively select from a diagram. The device continues based on the medical database tree, until all necessary results are taken in while the patient is still waiting to be seen. The health care provider will, after receiving the device, change the orientation to receive all relevant information in the target language based on relevant categories (eg. History, symptoms, severity, frequency, etc..). The health care staff is the encouraged to select the series of tests they intend to perform, and upon returning the device to the patient and changing the orientation, instructions will vocalize for the patient explaining what procedure is taking place, its intention, and how to respond to the health care provider (eg nodding, etc..) and will request any necessary prompts from the patient as required. At the end of the interaction, the doctor is encouraged opt into enter their final diagnosis for the purpose to collecting metrics in on diagnostic tests and disease.



Initial screen seen by physician or triage nurse

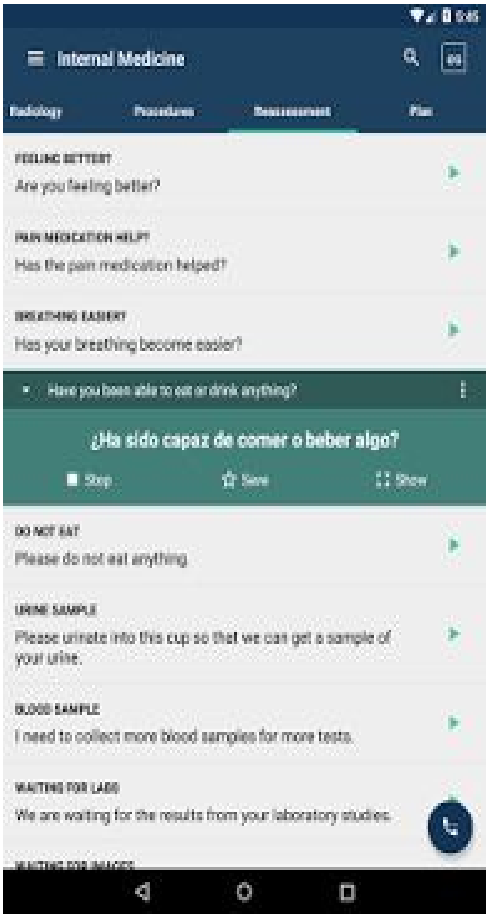
Interactive response node in pain history tree, in “patient side” orientation



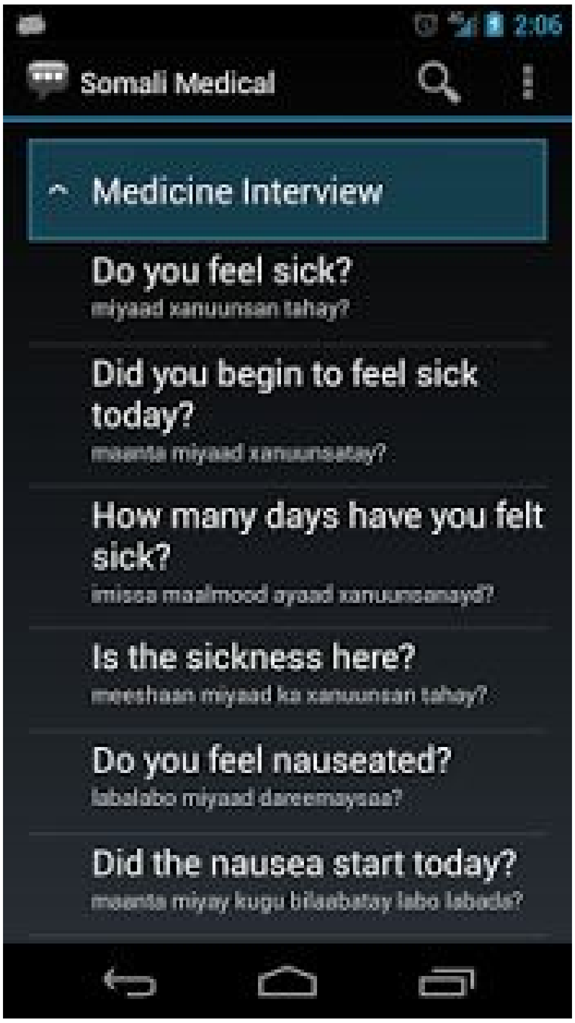
Results from interactive pain history node, seen by physician

5. Proof of performance (2 page maximum) Prove that your prototype meets the minimum required performance specifications. Include the results of validation tests and measurements of relevant aspects of the prototype’s performance. Provide quantitative evidence that your prototype meets or exceeds the minimum performance specifications and provides a superior solution to that of existing designs.

As mentioned, current designs are rudimentary phrasebooks:


Internal Medicine
FEELING BETTER?
Are you feeling better?
PAIN MEDICATION HELP?
Has the pain medication helped?
BREATHING EASIER?
Has your breathing become easier?
Have you been able to eat or drink anything?
¿Ha sido capaz de comer o beber algo?
DO NOT EAT
Please do not eat anything.
URINE SAMPLE
Please urinate into this cup so that we can get a sample of your urine.
BLOOD SAMPLE
I need to collect more blood samples for more tests.
WAITING FOR LABS
We are waiting for the results from your laboratory studies.


BACK
Results
Are you coughing up blood with the shortness of breath?
Did the baby have any breathing problems at birth?
Did the shortness of breath start gradually?
Did the shortness of breath start suddenly?
Do you cough with the shortness of breath?
Do you have ankle swelling with the shortness of breath?
Do you have blurry vision with the shortness of breath?
Do you have chest tightness with the shortness of breath?
Do you have difficulty breathing when you are upset?


2:06
Somali Medical
Medicine Interview
Do you feel sick?
miyaad xanuunsan tahay?
Did you begin to feel sick today?
maanta miyaad xanuunsaatay?
How many days have you felt sick?
imissa maalmood ayaad xanuunsanayd?
Is the sickness here?
meeshaan miyaad ka xanuunsan tahay?
Do you feel nauseated?
labalabo miyaad dareemaysaa?
Did the nausea start today?
maanta miyay kugu bilaabatay labo labada?

What we have been able to deliver is a superior patient doctor communication without the need for an interpreter. Our device has not yet been implemented in a health care setting, but we have been running lifelike simulations with the help of our hospital's centre for simulation based learning. We found that without the ability to directly communicate, the patient was able to enter their history and symptoms into the app before the doctors arrival, the doctor was able to walk into the room and immediately understand the issue, and successfully diagnose in 11 out of the 14 tests we performed. We also tested with other methods and apps, and found a flaw in our tests as most subject were bilingual and culturally identical, and knew how to communicate with the doctor via body language, which will not be the case cross culturally. Despite this, our method was able to bring on the diagnosis minutes faster, and seemed to leave both parties with greater satisfaction. Patients in all simulations expressed feeling involved in the health care and appreciating detailed explanations, though interestly one common feedback from the doctors' perspective was that the explanations of what was being done to the patient could be less detailed and shorter to better fit their workflow.
We are working closely with our community to ensure that the app fits seamlessly into the natural flow of the doctor without having to teach or require from anyone new skills.

6. Business plan for manufacture and distribution of the technology (3 page maximum)
Propose a method of manufacture and distribution of the technology.
This should include detailed estimates of the costs of manufacture and distribution, as well as a plan for funding the technology.
Issues to consider:
Will there be a paying customer for the final product? If so, who will the customer be (developing world health care clinics, international charities/NGOs, developed world clinics in addition to the developing world clinics, etc.) and how much revenue can you expect to generate from sales of the final product?

We plan to release the technology freely to charities, and charge private clinics in developed regions. We are aiming for per use charge of $25, or a subscription model that allows 1400 patients for $10 each. In our research we found that certain immigration clinics who saw about 7000 unique non-native speaking patients could not meet the language needs of about 20% these clients. These clinics were not able to afford the $100/hr min 3 hours for professional interpretation services, and had quite a restrictive operation budget. Our market interviews discovered that $10 was a reasonable price per patient, generating $14 000 per single clinic per year, for the poorest of clinics.

This is on a local scale, and our solution is certainly scalable across the world because of its software nature. We are able to correlate any two languages on a one-to-one map of phrases and diagnostics, providing it an application across the world. According to CB Insights, the global industry in mobile health applications was 334 million USD, while machine translation was 2 Billion USD in 2014. Furthermore, our service can expand to other domains where there is a standard and limited scripts and tasks, such as law and policing.

How will the technology be funded?
We have had the good fortune of receiving resources and mentorship from the University of Toronto's Engineer Hatchery Incubator, who at this stage is connecting us with partners, grants, and investors.

I*s the technology sustainable with sales, or does funding from an outside source need to be secured to manufacture the technology?*
We were fortunate to have a dedicate team to minimize out developmental costs. Some of our earlier models were very capital intensive, but our collaborative economy model of generating the intelligence of our platform allows us to freely take advantage of idle health care professionals such as International Medical Graduates waiting to complete certification, medical residents, students, nurses, etc… We have found the desire to be involved quite positive in these groups, though we have plans to gamify this experience to provide further motivation to participate.
Our greatest cost will be with regards to expanding beyond our own geographic region. We plan to mitigate this cost by partnering up with existing global channels, such as translators without borders, but will have costs in the future to address areas where channels do not already exists.

Is there a startup investment necessary to get the technology to the point of sustainability?
We are fortunate to have the opportunity to seek startup investment, which will help us maintain the functionality of our software, and expand globally.

What options exist for funding the technology?
We are currently in talks with private entities interested funding our solution, and have appointments with relevant government bodies to push for grant funding.

How will the technology be manufactured?
It is available for download through relevant app stores.

Will it be manufactured in developing world settings? Is there enough manufacturing capital locally to construct the technology? How would this option affect the materials or construction techniques used in manufacture, and what impact might developing world manufacturing have on the local economy? Will the technology be manufactured in developed nations and then distributed to developing countries?

As mentioned in a previous section, our solution is electronic, and virtually accessible to any population where a health care provider has access to a mobile phone or tablet. This is an infrastructure that research suggests exists and is growing in the developing world. One aspect we especially considered in terms of accessibility is the largely aging population across the globe, and the possibility for illiteracy, and believe our solution is unique in using iconography and voice to bring usability to these populations.

How will the technology be distributed? Will it be distributed by charities/NGOs to developing countries throughout the world? Will the technology be distributed throughout a particular country or region to address a local need?
What partnerships may need to be formed with international organizations or with developing world governments and agencies to achieve effective distribution?

As mentioned previously, we have access to many cross-border organization who headquarter in our city. We plan to give these organizations free licence to distribute to medical staff in regions served by these charities and non-profits, and advocate on our behalf for the wellbeing of the patient. We have already established a few allies and influencers, and believe the adoption of the tool will demonstrate its efficacy rapidly. We will also set up a conference fund to be able to expose our solution directly to health care staff on the frontlines. Feedback from these organizations will guide the direction we take to address local marginalized populations.

What regulatory and intellectual property issues affect the technology?
Will you seek a patent for the technology?
We have not yet consulted with a lawyer to determine if our solution fits the criteria for a patent. Given the global goal of the solution, we find it hard pressed to patent globally.

Must your technology be cleared/approved by the FDA, CE, or any other international regulatory groups for it to be effectively implemented and accepted?
We face a liability issue in developed countries with regards to the accuracy of the translations. We make every effort to ensure the accuracy of the translations. With advice from legal counsel, we log every interaction with the software in a time stamped manner and are developing strategies to work with insurance providers, as our solution is likely to reduce malpractice.