Mitacs
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Mitacs Accelerate Proposal Application

INSTRUCTIONS

- Please make sure you are using the latest version of this form posted on **www.mitacs.ca/en/programs/accelerate/apply-now**
- Please **do not modify, remove** text or instructions in each section/subsection **or reformat** this form in any way. A modified form will result in a delay in the internship evaluation process.
- Detailed information on how to write your proposal can be found in the *Accelerate Guide: Writing your proposal document*.
- Send your draft proposal to your Mitacs Business Development Representative **prior** to obtaining all signatures and submitting.
- The proposal should be written and submitted **at least eight (8) weeks prior to the planned start date of the internship. For international travel, a minimum 16 weeks lead time is required.**
- The start date of the internship has to be **after** research approval and the **receipt** of the partner funds at Mitacs.
- Partner funds can be sent directly to Mitacs in Canadian dollars prior to approval to expedite the process.
- If applicable, proposals with a not-for-profit partner must seek partner and project eligibility approval before proceeding. Please contact a Mitacs Business Development Representative to discuss the eligibility of an NFP organization **BEFORE** submitting your application (see section 2.7).
- If applicable, conflict of interest declarations must be received by Mitacs **before** submitting your application (see section 4.1/4.2/4.5).
- If you cannot see the items listed in the drop downs, please refer to the Appendix B: Options and type the corresponding answer on the space provided.

Please note:

If required, your **Mitacs Business Development Representative** can assist you with:

- Identifying your Office of Research Services (ORS) or equivalent representative.
- Assessing the eligibility and completeness of the proposed research.

APPLICATION CHECKLIST

A complete internship application package must include the following:

- ☐ The proposal application **completed and signed** by all parties in Word form. *The Mitacs Accelerate Memorandum* (see Section 7) with signatures must be submitted as a scanned PDF file.
- ☐ List of six external expert, arms-length reviewers and their contact information.
- ☐ Intern(s) CV (a CV template is available on the Mitacs website).
- ☐ Lead Academic Supervisor's CV **only** for projects with **6+ IUs** (CCV as per Tri-Council or other CV format).
- ☐ Excel budget spreadsheet: *Accelerate Resource Plan and Invoicing*.
- ☐ Any supplementary documents (as applicable).
- ☐ Appendix A - Accelerate Intern Consent Form signed.
- ☐ Indemnity Agreement (as applicable)*

*Please contact your Business Development representative to find out whether this document is required.

If your application involves an international component please note:

☐ International Pre-Departure Form and Code of Conduct and Ethics form may be forwarded to Mitacs after submission of your application; however, funds cannot be released and internship may not begin until Mitacs receives these forms

☐ Visit the Accelerate International website to determine if there is any additional required documentation for the country you intend to work with

* **An incomplete application or a modified form will result in a delay in the internship evaluation process.**

For more information, contact a **Mitacs Business Development representative.**

Mitacs Accelerate Proposal Application

1. Research Proposal Summary

1.1.	**Title of project:**	Detecting Credit Transaction Fraudulent Behavior Using Recurrent Neural Networks		
1.2.	**Type of project:** Please indicate (x) Select all that apply	(X) Standard		
		(_) Cluster (minimum of 6 internships and 3 interns)		
		(_) Accelerate International		
1.3.	**Number of Internship units:**	1		
1.4.	**Keywords to identify reviewers:** (3-10 specific keywords; 50% technically related, 50% discipline-related)	Recurrent Neural Network, Machine Learning, Artificial Intelligence		
1.5.	**Academic discipline:**	Engineering		
1.6.	**Project priority sectors:**	Finance & Insurance	Commercial Services	Information & Communications Technology
	Please **rank up to three** top priority sector(s) of your project:	1	2	3

1.7. List of participants:

Academic Supervisor	Department	Academic Institution	City and Country location of academic institution
Dr. Lourdes Peña-Castillo	Computer Science	Memorial University	St. John's, Canada

Partner organization(s)	Contact name at partner organization	City and Country location of organization	Partner Legal Status
VERAFIN	Marvin Chaulk	St. John's, Canada	For Profit Private Corporation
			Select Legal Status

1.8. Proposed work plan for internship unit(s) (IU):

Please summarize the work plan for the project by showing which intern will work when. This table provides a high level overview of the proposed research project and information about intern(s) to the reviewers. Please refer to the **Accelerate Guide: Writing your proposal** to assist you.

	Years	Year 1						Year 2						Year 3					
	Months	1-4		5-8		9-12		1-4		5-8		9-12		1-4		5-8		9-12	
Intern Name	Degree Program	IU																	
Ruben Chevez	MSc.	1	X	X															

Total Internship Units	**1**																		
Total Project Funding	**$ 15,000**																		

For projects with international travel only:

1.9 Does this project create new international collaborations? ( ) Yes (X) No*

*If this project is connected to an existing international collaboration, please briefly describe the collaboration. Include a summary of the collaboration, duration of the collaboration, and any past exchange of personnel, etc.

2. Description of Proposed Research

2.1. **Project title:** Detecting Fraudulent Behavior in Credit Transactions Using Recurrent Neural Networks

2.2. **Research Abstract** (Approx. 200 words):

Please include: Research problem to be addressed and its significance, objectives, and proposed methodology. This section will be used to recruit reviewers; it differs from section 7.2. (Public Project Overview) and must clearly summarize the research proposed.

Fraudulent activities are very hard to detect due to the low amounts of incidents per sample of historical data, but they can cost millions of dollars in monetary losses and legal costs to financial institutions. The unbalance dataset can make it hard for engineers and computer/data scientists to design and use machine learning models. Machine learning is a broad field of study with many branches, but the focus of this research project is a special model that can retain information through time; it can be thought as a machine learning model with a memory component. This machine learning model is called Recurrent Neural networks (RNN). This study will focus on an overview of the distinct types of RNNs, their advantages and disadvantages, best practices, available resources, and their contribution in the fields of financial services & banking, and fraud detection. Additional to the theoretical analysis, a practical component will be included in the study describing the publicly available credit transactions datasets, and code implementation of the different variants of RNNs.

2.3. **Background** and review of relevant prior work (minimum 500 words):

Fraudulent behavior is currently detected by ruled-based systems that are unable to deal with explosively growing information data. (Li, Yu, Luwang, & Zheng, 2017) Machine learning models are being slowly being adopted in the industry, and some of the major roadblocks are the typical unbalanced data that is available and the black-box model behavior that makes it difficult to explain the outcome of a prediction. The following research papers describe different strategies used to exploit the advantages of the Recurrent Neural networks in detecting fraudulent behavior.

According to (Raghavendra & Lokesh, 2011), credit transactions in the digital age have made business transactions more efficient but come at a cost. The fact that neither the card nor cardholder need to be present at the point-of-sale, makes it difficult to authenticate if the costumer is really the card owner. Raghavendra & Lokesh's study focusses in the implementation of Feed Forward Neural Networks (FFNN) with genetic algorithms to find the best hyperparameters, but what is more important for our scope of interest are the types and sub-types of fraud described by the authors. (Raghavendra & Lokesh, 2011) states that the types of fraud techniques can be divided in Merchant-related Frauds, and Internet Related Fraud. Merchant Related frauds can be divided in Merchant Collusion and Triangulation. Internet Related Frauds can be divided into Site Cloning, False Merchant Sites, Credit Card Generators, Lost/Stolen Cards, Account Takeover, Cardholder-Not-Present, Fake and Counterfeit Cards, Erasing the magnetic strip, Fake Credit Card, Skimming, and Phishing.

(Wiese, 2007) reaffirms the main motivation for better fraud detection algorithms, the restriction and control of potential huge monetary loss due to fraudulent activity. In 2004, £504 million was lost on the UK credit transaction due to fraudulent activities. (Wiese, 2007) defines the problem statement as follows, “Given a sequence of transactions, can a classifier be used to model the time series inherent in the sequence to such an extent that deviations in card holder shopping behavior can be detected regardless of the skewness and noise inherent in the data. In addition, our classifier must exhibit both a high probability of detection and a low false alarm rate during generalization.” The study compares the performance of the algorithms Feed Forward Neural Networks (FFNN), Support Vector Machine (SVM), and the Recurrent Neural Network variant called LSTM with a dataset of a total of 30876 transactions evened out over 12 months with a class distribution of 99:1 between legitimate and fraudulent transactions. It also explains the disadvantage of FFNN due to their lack of capacity to handle sequence data. It uses mean squared error (MSE) and ROC curve area (AUC) as the performance measure. Some of the selected features are the transaction date, transaction amount, cardholder age, account age, months-to-card expiry, cardholder country, standard industry code of merchant, and two velocity counts. LSTMs outperformed the other methods in terms of MSE and AUC and their training times were shorter.

(Ando, Gomi, & Tanaka, 2016) explains their architecture and implementation of LSTMs, their methodology used for training, and problems to avoid such as vanishing and exploding gradients. In their article they also explain the data encoding and F-measure as their performance metric. The study proves that RNN are superior to other machine learning techniques in fraud detection using sequential data. (Li, Yu, Luwang, & Zheng, 2017) introduces a GRU, a different variant of RNN, to detect fraud transactions and explains the differences between GRUs and LSTMs.

Kaggle is well known to offer a big set of publicly available datasets including Credit Card Transaction datasets such as (Machine Learning Group - ULB, 2018) and Jupiter notebooks called kernels design by users of the platform to utilize each dataset. In this proposed study, a detailed survey on available resources (datasets) will be performed and different alternatives will be explored to implement RNNs to detect fraudulent transactions with sequential and unbalanced data to be evaluated.

2.4. **General objective** of the research project broken down into sub-objectives, activities, themes, or subprojects, as applicable:

Objective: To perform an empirical study to evaluate the performance of RNN for fraudulent behaviour detection. The sub-goals are:

- Identify available fraudulent transactions datasets suitable for the study.
- Conduct a literature review on standard prediction approaches for fraud detection to select a suitable approach as baseline for comparison with RNN.
- Conduct a literature review on strategies for training Recurrent Neural Networks on imbalanced datasets.
- Provide practical implementations on RNN variants and evaluate their performance on public datasets in comparison with the performance of the baseline approach.

2.5. Details of internships or subprojects:

For each intern or subproject, provide the following mandatory information:

a. **Name of intern.** **RUBEN ANTONIO CHEVEZ GUARDADO**

b. **Specific objectives of the internship or subproject**. Clearly state your [sub-] objectives so reviewers can assess if they are achievable.

- Conduct a literature review on standard prediction approaches for fraud detection to select a suitable approach as baseline for comparison with RNNs.
    a) Approaches and their performance metrics
        a. Decision trees (i.e. Random Forest)
        b. Neural networks
        c. SVMs
    b) Advantages and disadvantages of the baseline approaches
    c) Previous work done with RNNs
    d) Advantages and disadvantages of RNNs in fraud detection.
- Conduct a literature review on strategies for training on imbalanced datasets.
    a) K-Fold cross validation.
    b) Evaluation metrics.
    c) Oversample minority class.
    d) Under-sampling majority class.
    e) Generation of synthetic samples.
    f) Early stopping Early stopping
- Identify available fraudulent transactions datasets suitable for the study.
    a) Compile a list of publicly available datasets from public repositories and literature.
        a. Open-sourced Credit Card Transaction Datasets
    b) Investigate the possibility of generating synthetic data from available datasets based on the probability distribution of the data points.
- Provide practical implementations on RNN variants and evaluate their performance on public datasets in comparison with the performance of the baseline approach.
    a) Data preprocessing
        a. Eliminating duplicate data points and reduce outliers
        b. Normalizing the data
    b) Data transformations required for RNN models
    c) The implementation of state-of-the-art recurrent neural network models in open-sourced frameworks.
        a. Long Short-Term Memory - LSTM
        b. Gated Recurrent Units - GRU
    d) Benchmarking of baseline approaches vs RNNs performance results.
    e) Results and analysis:
        a. Create a visual representation of the results
        b. Create conclusive statements based on the results
        c. Add the resulting content on the research article and the GitHub repository

Methodologies. Provide enough detail so reviewers can determine if the proposed methodology is appropriate and sufficient to achieve the [sub-] objectives.

- **Literature Source**: The first objective is to conduct a literature review on standard prediction approaches for fraud detection to select a suitable approach as baseline for comparison with RNN. Examples of such methods are decision trees, SVMs, and neural networks. Search engines, such as Google or Bing, are good places to start. Online scholarly databases, such as Google Scholar, IEEE Xplore, and EBSCO, will be the main focus. Research databases or journal articles can provide insights into current solutions in the field. Also, articles in the media could have brief, up-to-date insights about the problem, and the implications for financial institutions.

- **Dataset**: Fraud datasets are not widely available online because of the sensitive information that can contain such as names, addresses, financial accounts, etc. Some institutions have been able to publish such information securely by anonymizing the features in the dataset. They usually contain only numerical input variables which are the result of a (Principal Component Analysis) PCA transformation, except the time and the transaction monetary amount. PCA is a dimensionality-reduction method by transforming a set of variables into a smaller one that still contains most of the information of the largest data set. This method comes at the expense of accuracy for simplicity. (ULB, 2019) is an example of this type of datasets available online. It contains anonymized transactions from European cardholders from September 2013. Other dataset sources can be university and researchers' websites, Amazon Datasets, Google Datasets Search Engine, Microsoft Datasets, GitHub, Gitlab, Government Datasets, and FiveThirtyEight.

- **Frameworks & Libraries**: There are many machine learning Frameworks from which to choose, such as Keras, Tensorflow, Pytorch, Sklearn, Theano, CNTK, Caffe, MXNET and more. For this study, Keras will be used for its simplicity and high-level programming interface. Keras can work on top of Theano or Tensorflow, but Tensorflow will be used due to the variety of features it contains such as Tensorflow Serve, Tensorboard, GPU computing compatibility and more. Sklearn contains tools for data split and hyperparameter selection, such as KFold and GridSearchCV, that are compatible with Keras. NumPy is a mathematical library that will be useful during the transformation and normalization of the data. Matplotlib is a visualization library that will play an important role during the analysis of the results.

- **Data Transformation**: One Hot Encoding and Normalization will be the main processing steps to prepare the data before feeding it to the machine learning models. One Hot Encoding is usually used to convert categorical data into numerical data. It works by representing each feature as a set of binary numbers. Normalization is a technique often applied to change the values of numerical columns to a common scale without distorting differences in the range of the values. The Sklearn's train_test_split component will be used to separate the data in training and testing sets. The KFold component will be used to separate the training data into k sets to train in batches.

- **Computational Platform**: There are many platforms available; many of them offer free computing power during a set timeframe or capacity. Google Collaboratory offers free Jupyter notebooks running for 12 hours on Google CPUs and GPUs. AWS offers 12 months of free tier services, but they are normally limited. Microsoft Azure also offers similar services. Compute Canada is free to use for members. Any of the platforms will work but it will depend on the computation and time requirements.

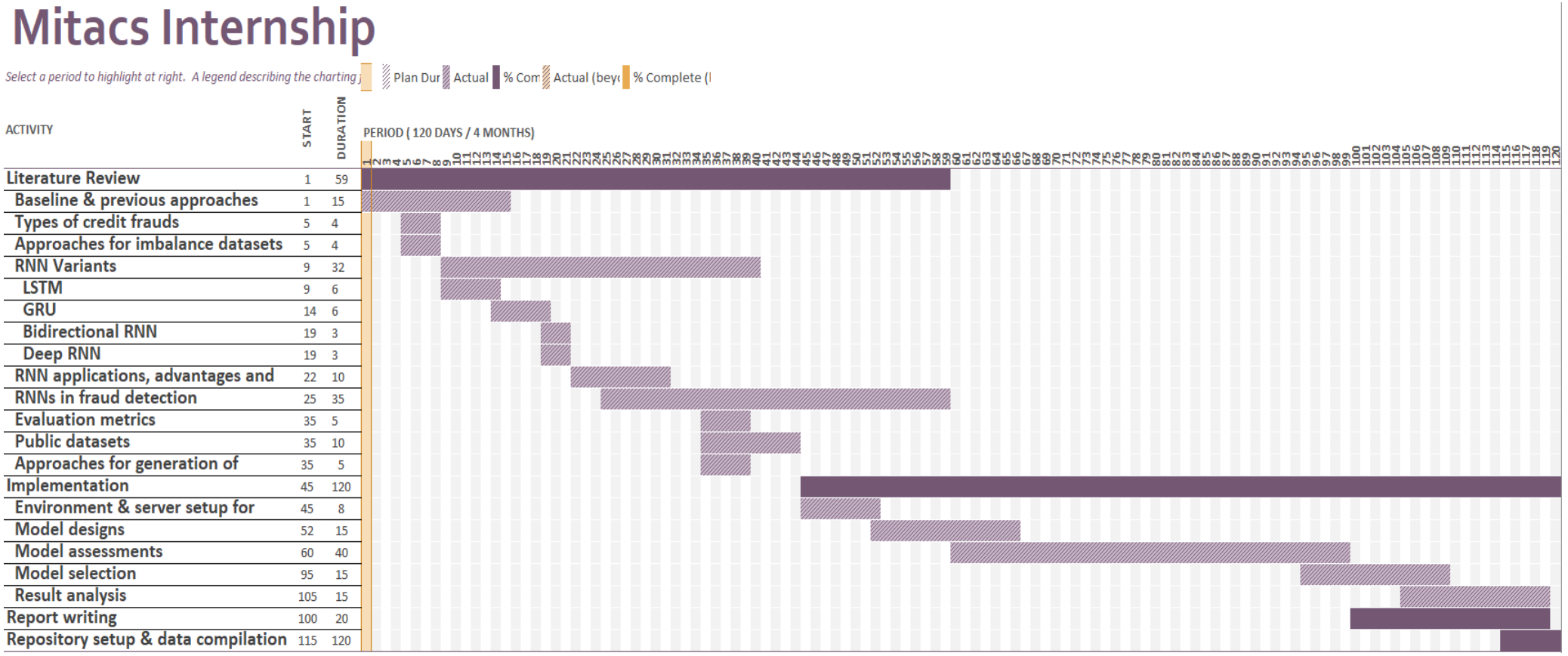
- **Model Architecture**: Keras contains recurrent layers, such as GRU and LSTM. Keras is very easy to use because it allows to stack many layers on top of each other. The GridSearchCV component will be used for hyperparameter selection. ReLU is used as the activation function in the hidden layers and Softmax is used as the activation function for the output layer. Softmax is used for categorical classification. The network will have a binary classification output that describes the probability of being fraudulent in a range from zero to one. Binary Cross Entropy will serve as the loss function. Gradient Descent will be used to calculate the minima of the loss function. Backpropagation will be used to tune the parameters of the network until reaching the local minima of the loss function.

- **Evaluation Metrics**: The ROC and AUPRC curves will be used to evaluate the models. The AUPRC curve consists of the Precision and Recall (True Positive Rate). Precision is the

fraction of true positive instances among the predicted positive instances, while recall is the fraction of true instances that have been retrieved as positives over the total number of true instances. The ROC curve is plotted with TPR against the False Positive Rate (FPR) where True Positive Rate (TPR) is on y-axis and FPR is on the x-axis. If the number of negative instances is larger than the number of positive instances, also called imbalance dataset, precision is not affected by many negative samples and that is because it measures the number of true positives out of the instances predicted as positives (True Positives + False Positives). The ROC metrics measure the ability to distinguish between classes.

- **Benchmarking**: LSTMs and GRUs will be trained starting with a single hidden layer with a couple of hundredth neurons. Adding more layers will help see if the model underfits or overfits on the dataset. Early stopping, KFold Cross Validation and Dropout will help decrease the probability of overfitting. The RNN model's performance metrics will also be compared against the baseline model performance.

d. Timeline. We suggest using a Gantt chart to provide a timeline showing which task will be done when to achieve each objective.



e. **Expected deliverables.** Each project requires the submission of a completed Mitacs Final Report and Mitacs survey at the end of the project**.** Please describe the additional expected deliverables of the project i.e. expected outcomes, results, documents (intern's thesis, peer-reviewed journal, conference presentation).

- **Literature Review**: The empirical study on the viability of RNNs for fraud detection will provide insight of the advantages of RNNs over previous baseline prediction approaches. The research article will contain an expanded analysis of previous approaches, strategies, best practices for handling unbalanced datasets and sequential data.

- **Code**: The research article will also include programming code, pseudo-code snippets and references to a private GitHub repository containing the complete code implementation in python files and Jupyter notebooks.

- **Repository**: The GitHub repository will contain a Jupyter notebook which will explain step-by-step how to run the code in the repository plus the resulting graphs and output data from the algorithms. The repository will be private and only shared with the company's representatives. It will only be open-sourced if they decide to do so.

- **Results**: The results statements will be compiled based on experimental outcomes of the RNN model's performance over the datasets and its performance comparison with other baseline approaches. The result statements will be complemented with visual representation such as Precision-Recall curves, ROC curves, grid-search hyperparameter table and performance comparison, training cross-validation performance, test and validation performance.

- **Expected outcomes:** A complete empirical study of RNN's advantages, disadvantages, methodology, implementation, performance, and benchmarking over current baseline models for unbalanced, anonymized, and sequential fraud detection datasets.

-**Mitacs Final Report and Survey**

f. **Benefit to the intern.**

As the popularity of machine learning increases every year, the demand for high qualified personnel with ML expertise grows as well. The demand for skilled engineers with this knowledge grows as well. This project will expose the intern to state-of-the-art RNN architectures and will provide practical experience implementing and assessing the performance of an RNN for fraud detection. Additionally, it will provide experience conducting industry-relevant research with a well-known company such as Verafin. This collaborative research experience will increase the possibilities of obtaining employment at the industry partner or a similar company. The research also relates directly to the intern's thesis topic.

Interaction. Indicate the percentage (%) of time during the project that the intern will spend on-site at the partner's location and at the academic institution(s). Research should be carried out equally (50%) in the premises of the partner and the academic institution(s), if different, please include a **justification**. NOTE: The minimum interaction at either site is 25% with a maximum of 75%.

% of partner interaction: **50** % **+** % of academic interaction: **50** % = 100%

If internship involves international travel, please complete the following:

% of partner interaction: ____ % **+** % of home academic interaction ____ **+** % of host academic interaction: ____ % = 100%

Do any interns expect to spend more than 12 consecutive months outside of their home country? If yes, Mitacs may request additional information.

g. Partner Interaction.

Provide a detailed description of the activities that will be performed on-site at the partner organization and the expected interaction with and supervision by employees of the partner organization.

The time spent on-site at Verafin will help the intern understand the methodologies currently being used to research and assess fraudulent behavior detection and to learn from the expertise from the team of experienced engineers who are working on developing these systems. Learning the pain points that currently are affecting the performance of the systems. Understanding the privacy agreements that prevents the company from sharing information and find ways of work together without violating any privacy terms from their clients. The intern will receive 1-on-1 mentoring and feedback from the employees in the organization. The intern will participate in weekly team meetings and work directly with the company team leads working on the assessment of fraudulent behavior detection.

(1) Indicate the resources the partner organization will be providing to support the intern's work at their premises. Include information about space, resources and expertise that will be provided by the organization to the intern.

The resources consist of a space to work in while being in the partner organization's facilities, expertise, mentoring and access to team members with expertise in the research area. The partner organization will provide internet access, along with the necessary hardware, software and data sets that are necessary for the intern to conduct the research.

2.6. Relevance to the partner organization and to Canada:

Describe the partner's proposed role in the project, how the partner will benefit from participating, and how the Canadian community will benefit from this research.

The ICT sector makes a substantial contribution to Canada's GDP. In 2017, the sector's GDP was $83.5 billion (in 2012 constant dollars),and accounted for 4.4% of national GDP. Ensuring the innovation and growth of the sector is important to the Canadian economy (source: https://www.ic.gc.ca/eic/site/ict-tic.nsf/eng/h_it07229.html). Verafin is one of the largest software companies in Atlantic Canada with over 400 employees; many of whom have graduated from post-secondary institutions in the region. In order for the company to remain competitive, it needs access to research in this subject matter area, supported by the intern and his academic supervisor. Also, increasing the research in the area of machine learning will position Canada as one of the pioneer countries in developing the technology.

2.7. Project economic orientation (for submissions with a NFP organization ONLY):

Describe the economic or productivity orientation of the project. NOTE: if any partner listed in this proposal is a not-for profit (NFP) organization, please contact a Mitacs Business Development representative to discuss its eligibility before proceeding with your proposal submission.

- N/A

2.8. Relationship (if any) to past/other Mitacs projects:

Describe whether or not the current project is related AND provide specifics about the relationship (e.g. not related because it refers to a different research area OR if related: provide information about what has been achieved in past projects and how the current application complements other submissions)

- N/A

2.9. References:

Ando, Y., Gomi, H., & Tanaka, H. (2016). Detecting Fraudulent Behavior Using Recurrent Neural Networks. Computer Security Symposium.

Li, X., Yu, W., Luwang, T., & Zheng, J. (2017). Transaction Fraud Detection Using GRU-centered Sandwich-structured Model; Xuetao Qiu; Jintao Zhao. Arxiv.

Machine Learning Group - ULB. (2018, 03 22). Retrieved from https://www.kaggle.com/mlg-ulb/creditcardfraud

Raghavendra , P., & Lokesh , S. (2011). Credit Card Fraud Detection. International Journal of Soft Computing and Engineering (IJSCE).

ULB, M. L. (2019). Credit Card Fraud Detection. Retrieved from Kaggle: https://www.kaggle.com/mlg-ulb/creditcardfraud

Wiese, B. J. (2007). Credit Card Transactions, Fraud Detection, and Machine Learning: Modelling Time with LSTM Recurrent Neural Networks. In Innovations in Neural Information Paradigms and Applications. Springer.

Declarations

3.1. Will the proposed research be taking place outside of the lab or normal business environment?

Yes___ No X___

If yes, please complete the following section to indicate what (if any) impact there may be on the environment.

a. Main characteristics of the location (i.e. physical description & coordinates).

b. Principal activity(ies): for each activity, list the environmental elements affected.

c. Are authorizations, permits, or licenses required to undertake any activity during the internship?
Yes___ No___

If yes, please list and include copies with your application.

3.2. Does the proposed research involve living human subjects (including conducting interviews) or human remains, cadavers, tissues, biological fluids, embryos, or fetuses?

Yes___ No X___

If yes, the proposal must be approved by the participating academic institution's Research Ethics Board*, and a valid Ethics approval is required for the duration of the research project. Access to funding may be denied for projects that do not have ethical approval.

Please note: Mitacs may request a copy of the report to ensure compliance.

3.3. Does the proposed research involve animal subjects?

Yes___ No X___

If yes, the proposal must be approved by the participating Institution's Animal Care Committee*, and a valid approval from the committee is required for the duration of the research project.

Please note: Mitacs may request a copy of the report to ensure compliance.

3.4. Is a biohazards review required?

Yes___ No X___

If yes, the necessary review/report must be conducted in accordance with your academic institution's policies*, and a valid biohazards approval is required for the duration of the research project.

Please note: Mitacs may request a copy of the report to ensure compliance.

3.5. Have any participants declared a Conflict of Interest (COI)* as part of this application?

Yes___ No X___

If yes, please attach the signed conflict resolution letter.

** if you have any questions about the requirement for Research Ethics/Animal Care/Biohazards review or academic institution/Conflict of Interest Policies at your institution, please contact your corresponding institution's research office.*

4. Participants

Duplicate relevant section(s) as needed for multiple interns or supervisors.

4.1. Academic supervisor in Canada:

Name:	Dr. Lourdes Peña-Castillo
Academic Institution:	Memorial University of Newfoundland
Department:	Computer Science
Address (at academic institution):	230 Elizabeth Ave
City, Province, Postal Code:	St. John's, NL, A1C 5S7
Phone:	(709) 864 6769
Permanent Email:	lourdes.pena@mun.ca
Alternative E-mail:	lourdes@mun.ca

4.1.1. Is the academic supervisor**:

a. An owner or a co-owner of the partner organization: Yes___ No X___

b. A relative of an owner or co-owner of the partner organization: Yes___ No X___

c. An employee of and/or a participant in the day-to-day management of the partner organization: Yes___ No__X

d. A relative of the intern and/or partner supervisors of the proposed project: Yes___ No X___

If yes to any of the above, please click here to complete the **Conflict of Interest Declaration** and send it to accelerate@mitacs.ca **BEFORE** submitting your application.**

For any additional academic supervisors in Canada, copy and paste Section 4.1. below:

4.2 Academic Supervisor abroad (if applicable):

Name:	---
Academic Institution:	---
Department:	---
Address (at academic institution):	---
City, Country:	---
Postal Code:	---
Phone:	---
Permanent Email:	---
Alternative E-mail:	---

4.2.1. Is the academic supervisor**:

d. An owner or a co-owner of the partner organization: Yes___ No _

e. A relative of an owner or co-owner of the partner organization: Yes___ No ___

f. An employee of and/or a participant in the day-to-day management of the partner organization: Yes___ No _

e. A relative of the intern and/or partner supervisors of the proposed project: Yes___ No_

If yes to any of the above, please click here to complete the **Conflict of Interest Declaration** and send it to accelerate@mitacs.ca **BEFORE** submitting your application.**

For any additional academic supervisors copy and paste Section 4.2. below:

4.3. Partner organization in Canada (if applicable):

Legal name:	VERAFIN	
Operating name (if different):		
Contact name:	Marvin Chaulk	
Position:	VP, Administration	
Department:	Administration	
Address:	18 Hebron Way	
City, Province, Postal Code:	St. John's, NL A1A 0L9	
Phone:	7096975045	
Email:	Marvin.chaulk@verafin.com	
Website:	verafin.com	
Partner size (number of employees):	100-499	---
Legal status:	For Profit Canadian Private Corporation	---
If Not for profit Canadian Corporation	Select NFP Type	---
NAICS Code (First three digits)*:	511	
* Click here for a list of North American Industry Classification System codes.		
Is this the **first time** the partner has collaborated with the academic institution? :	Yes	

For any additional partner organization in Canada copy and paste Section 4.3. below:

4.4. Partner organization abroad (if applicable):

Legal name:	---	
Operating name (if different):	---	
Contact name:	---	
Position:	---	
Department:	---	
Address:	---	
City, Postal code:	----	
Country:	---	
Phone:	---	
Email:	---	
Website:	---	
Partner size (number of employees):	Select No. employees	---
Legal status:	Select Legal Status	---
NAICS Code (First three digits)*:	---	
* Click here for a list of North American Industry Classification System codes.		
Is this the **first time** the partner has collaborated with the academic institution? :	Select yes/no	---

Please note that the financial contribution of organizations with permanent establishments in Canada may be subject to any applicable Goods and Services Tax (GST), Harmonized Sales Tax (HST) and/or Quebec Sales Tax (QST) (collectively VAT).

For any additional partner organization abroad copy and paste Section 4.4. below:

4.4.1 Invoicing Partner Contact

Partner contributions must be received by Mitacs BEFORE any funds are awarded to the academic institution. **Costs can only be incurred after research approval of the proposal** and the **receipt** of the partner funds at Mitacs**.**

a. Please describe any applicable **invoicing requirements** (vendor setup, PO, etc.):

Invoicing contact name:	Sarah Porter
Email:	ap@verafin.com

b. Invoicing Partner address:

X	Address same as filled in Section 4.3.
	Address same as filled in Section 4.4.
	If invoicing address different than Section 4.3 or 4.4, please fill out the following:

Legal name:	
Address:	
City, country, postal code:	
Name of contact:	
Phone:	
Email:	

c. Have these funds been leveraged against other federal or provincial programs? Yes___ No_X__

If yes, please provide details:

4.4.2 Partner Funds at academic institution. *IF APPLICABLE*

To be completed only if Partner funds were sent as an exception to the academic institution**. If no** please proceed to section 4.5.:

a. Is there a **research agreement** in place with the academic institution that governs the use of these partner funds?

Yes__ No___

If yes please speak with your BD representative, fill out the *addendum to research agreement document*, and submit that document with your completed application.

If no please complete the following:

b. ORS/UILO or equivalent agrees to send these funds to Mitacs: Yes___ No___

If yes, please provide:

Academic institution account number:	

c. The partner agrees by signing this application that the funds can be forwarded: Yes___ No___

If yes, please provide:

Name of the consenting partner representative	

d. Invoicing academic institution contact to receive Mitacs invoice:

Name:	
Department:	
Email:	

e. Is the GST or HST, and QST (if applicable) to be included with invoice to academic institution? Yes___ No___

If no, tax(es) will be invoiced directly to the industry partner.

4.5. Intern(s) identified:

4.5.1. Intern #1 information ** MANDATORY **

Name:	Ruben Antonio Chevez Guardado	
Degree program during internship (college/masters/PhD/PDF):	MSc. Computer Science	
Expected year of graduation:	12	2020
If PDF, indicate month/year PhD received:	MM	MM
Academic institution:	Memorial University	
Department:	Computer Science	
Address at academic institution:	230 Elizabeth Ave	
City, Province, Postal code:	St. John's, NL, A1C 5S7	
Country:	Canada	
Phone:	(709) 764 7777	
Permanent phone or Cell phone	(709) 764 7777	
Permanent email:	rubencg@mun.ca	
Alternative email:	rubencg195@hotmail.com	
Citizenship:	**Foreign**	If Foreign, please indicate citizenship: Honduran
Gender:	**Male**	
Will this intern conduct any internship units at a partner organization outside their home country?*	No	
*If yes, please indicate anticipated **travel** dates	Start Date: DD/MM/YYYY End Date: DD/MM/YYYY	

4.5.2. Conflict of interest. Is the intern:

a. An owner or a co-owner of the partner organization: Yes___ No_X__

b. A relative of an owner or co-owner of the partner organization Yes___ No X___

c. An employee of and/or a participant in the day-to-day management of the partner organization: Yes___ No_X__

d. A relative of the academic and/or partner supervisors of the proposed project: Yes___ No_X__

If yes to any of the above, please click here to complete the **Conflict of Interest Declaration** and send it to accelerate@mitacs.ca **BEFORE** submitting your application.

4.5.3. Demographic information. **OPTIONAL**

Please indicate (x) if you are:

Francophone:	(_)	A person with a disability:	(_)
Indigenous:	(_)	First in your family to attend college or university:	(_)
Member of a visible minority group - *includes persons who are non-Caucasian in race or non-white in colour and who do not report being Indigenous*			(X)

Social Media: Please provide usernames if you wish to connect with Mitacs by social media:

LinkedIn:	https://linkedin.com/in/rubenchevez/	
Twitter:	https://twitter.com/rubencg195	
Facebook:	https://www.facebook.com/rubencg195	

For any additional interns copy and paste Section 4.5. below:

4.6. Intern(s) to be determined (TBD):

4.6.1. TBD#1

Degree program during internship (college/masters/PhD/PDF):	---
Academic institution:	---
Department:	---
Will this intern conduct any internship units at a partner organization outside their home country?*	Select yes/no
*If yes, please indicate anticipated **travel** dates	Start Date: DD/MM/YYYY End Date: DD/MM/YYYY

For any additional TBD interns, copy and paste Section 4.6. below:

5. Resource Plan and Invoicing

All Accelerate projects are required to complete the Accelerate Resource Plan and confirm the Invoicing schedule on the Excel Budget spreadsheet template. Please refer to the **Accelerate Guide: Writing your proposal** to assist you

6. Suggested Reviewers

6.1. Reviewer's comments. Please select ONE of the following:

___ We consent to receive reviewer's comments in either official language (French or English).
__X_ We request to only receive reviewer's comments in the language of which this proposal is submitted.

6.2. Please provide the names and contact information of at least **SIX (6) arms-length** reviewers.

An arms-length reviewer must:

- Be a recognized expert in the research topics and technical aspects covered by the proposal;
- NOT be from the same academic institution as the intern(s) or the academic supervisor(s); and
- NOT have had any collaboration with the intern(s) or the academic supervisor(s) or the partner(s) during the past five (5) years or planned for the near future.

Please note that neglecting to suggest reviewers who qualify as arms-length will delay the review of your application.

Reviewer 1:

Name:	Esma Aïmeur
Academic institution:	University of Montreal
Department:	Faculté des arts et des sciences
Email:	esma.aimeur@umontreal.ca

Reviewer 2:

Name:	Dr. Luis Torgo
Academic institution:	Dalhousie University
Department:	Faculty of Computer Science
Email:	ltorgo@dal.ca

Reviewer 3:

Name:	DR. MALCOLM HEYWOOD
Academic institution:	Dalhousie University
Department:	Faculty of Computer Science
Email:	mheywood@cs.dal.ca

Reviewer 4:

Name:	Martha White
Academic institution:	University of Alberta
Department:	Department of Computing Science
Email:	whitem@ualberta.ca

Reviewer 5:

Name:	Chen Xu
Academic institution:	UOttawa
Department:	Department of Mathematics and Statistics
Email:	cx3@uOttawa.ca

Reviewer 6:

Name:	Michael Bowling, PhD
Academic institution:	University of Alberta
Department:	Computing Science
Email:	michael.bowling@ualberta.ca

Potential conflict of interest. ***OPTIONAL***

Please list reviewers you would prefer Mitacs not to contact.

Name:	
Academic institution / Research Group:	

Name:	
Academic institution / Research Group:	

7. Mitacs Accelerate Memorandum

The participants listed below confirm that the information presented accurately reflects their intention to apply to the Mitacs Accelerate program. The participants have also agreed to set in place an internship based upon the attached proposal. The participants acknowledge that they have read, understood and agreed to abide by and uphold the Project Responsibilities applicable to each of them, available for reference at: http://www.mitacs.ca/en/programs/accelerate/project-responsibilities which include and are not limited to the following: It is understood that the partner organization contribution shall be provided to Mitacs Inc. in Canadian dollars prior to commencement of the internship; in the event that the sponsor organization funds are at the academic institution, the academic institution shall forward these funds to Mitacs. Upon research approval and the reception of the partner funds at Mitacs, Mitacs shall forward the funds to the Canadian academic institution as a research grant to the Canadian supervising professor, and the internship stipend/salary will be paid to the student by the academic institution from the grant. Costs associated with this proposal as outlined in the budget can only be incurred after research approval of the proposal and the receipt of the partner funds at Mitacs.

Mitacs is unable to assume liability for any losses including—but not limited to—accidents, illness, travel, or other losses that may occur during the internship period. All undersigned parties agree that they are responsible for ensuring that they have appropriate insurance and meet any institutional policies regarding health, safety, and travel preparation requirements. All parties also agree that the intern will provide Mitacs with a final report and that all participants will complete an exit survey within one month of project completion.

For projects involving international travel: In acknowledging that international exposure can greatly enhance an intern's learning and experience, Mitacs will approve international travel provided that participation does not impact the safety and security of the intern and meets the policies outlined by the home university. By signing this memorandum, you are acknowledging that the home university agrees to assist the intern in meeting all university requirements pertaining to research abroad and that the intern understands that he/she is responsible for obtaining insurance appropriate for the travel destination. Participants in projects involving international travel acknowledge that additional Project Responsibilities apply to each of them, available for reference at https://www.mitacs.ca/en/programs/accelerate/mitacs-accelerate-international. Participants in projects involving international travel also acknowledge that the internship cannot begin and funds cannot be released until Mitacs receives the signed International Pre-Departure Form and Code of Conduct and Ethics forms.

All parties involved with Mitacs Accelerate are bound by the standard intellectual property (IP) terms of the academic institution where the intern is enrolled; except where intellectual property is covered by separate agreements to which the academic institution(s) and the sponsor organization are parties and that are active during the dates of the internship. By signing this memorandum, you are acknowledging that you agree to the terms of the academic institution where the intern is enrolled. Institution-specific IP policies regarding Accelerate internships can be found at Frequently Asked Questions (FAQ).

The participants listed below agree that Mitacs can disclose the provided personal information included in this proposal (e-mail, LinkedIn, Twitter, Facebook, etc.) to the program's funding partners. Mitacs can use this information for the purpose of communication and to evaluate the program and its outcomes during and after participants' program tenure. The participants also agree that Mitacs will post the title of the project, the public project overview, the name of the partner(s) organization(s), the name of the intern(s), the name of supervisor(s) and the involved academic institution on www.mitacs.ca/en/projects and may be used by Mitacs to publicize Mitacs Accelerate. Mitacs Privacy Policy can be found at www.mitacs.ca/en/privacy-policy.

Internship participants (intern, supervising professor, and partner) further agree to the following addendum(s):

Mitacs does not require, inspect, or enforce any additional terms as outlined by participants in the above addendum.

7.1. Title of the Project: Detecting Fraudulent Behavior in Credit Transactions Using Recurrent Neural Networks

7.2. Public Project Overview:

Using simplified language understandable to a layperson; provide a general, one-paragraph description of the proposed research project to be undertaken by the intern(s) as well as the expected benefit to the partner organization. **(100 - 150 words)**

- Fraudulent activities are hard to detect, but they cost financial institutions millions of dollars in monetary losses and legal costs every year. Millions of dollars are being lost in credit transactions as criminals are finding new, more sophisticated ways to conduct financial crime. This research project examines novel ways of detecting fraudulent behavior using powerful tools such as Recurrent Neural Networks, a type of machine learning model that is well suited for sequence or historical data.

7.3. Participant Signatures:

Please sign, scan and save in PDF format

7.3.1. Intern:

Name:	RUBEN ANTONIO CHEVEZ GUARDADO	
Department:	COMPUTER SCIENCE	
Academic institution:	MEMORIAL UNIVERSITY	
	For interns participating in international travel: The intern acknowledges that additional Project Responsibilities apply to Accelerate International travel (as outlined in the Memorandum above) and agrees to abide by these additional program rules.	
Signature:		Date

7.3.2. Academic Supervisor in Canada:

Name:	LOURDES PEÑA-CASTILLO	
Department:	COMPUTER SCIENCE	
Academic institution:	MEMORIAL UNIVERSITY	
Signature:		Date:

7.3.3. Academic Supervisor abroad (if applicable):

Name:		
Department:		
Academic institution:		
Signature:		Date:

7.3.4. Partner Organization in Canada (if applicable):

Name:	Marvin Chaulk
Department:	Administration
Title/Position:	Vice President
Organization:	Verafin
Financial Commitment:	$7,500 + HST
	The partner organization commits to the funding contribution specified directly above and the payment schedules outlined in the attached *Accelerate Resource Plan and Invoicing*

	schedule. These are key conditions of the application and by signing below this proposal, the partner organization agrees to these conditions.	
Signature:		Date:

7.3.5. Partner Organization abroad (if applicable):

Name:		
Department:		
Title/Position:		
Organization:		
Financial Commitment:	$	
	The partner organization commits to the funding contribution specified directly above and the payment schedules outlined in the attached *Accelerate Resource Plan and Invoicing* schedule. These are key conditions of the application and by signing below this proposal, the partner organization agrees to these conditions.	
Signature:		Date:

7.3.6. Office of Research Services Representative or equivalent:

Name:		
Title/Position:		
Academic institution:		
Signature:		Date:

For any additional participants include corresponding details and signature line below:

Appendix A – Accelerate Intern Consent Form

USE AND DISCLOSURE OF PERSONAL INFORMATION PROVIDED TO MITACS

1. All personal information collected is subject to privacy legislation and Mitacs Privacy Policy for Program Participants. For a description of Mitacs' commitment to protect the personal information provided by program applicants, please see http://www.mitacs.ca/en/privacy-policy.
2. All the information supplied in this application will be made available to Mitacs staff responsible for managing the application, for activities including identifying appropriate peer reviewers, administering and monitoring awards, compiling statistics, and evaluating the program.
3. Information supplied in this application will be made available to internal and/or external reviewers, being composed of experts recruited from the academic, public and private sectors. All reviewers are required to commit to keep the application information confidential.
4. Contact information in this application may be used by Mitacs staff to contact you in future for:
   a. Invitations to be profiled in stories or news items, to speak at or attend events, to provide a spotlight story and/or blog post;
   b. Communications about opportunities for Mitacs alumni; and
   c. Research surveys for Mitacs alumni.

   You will have the opportunity to unsubscribe from emails sent to you, once all commitments regarding the internship that is the subject of this application are complete.
5. Your name, academic institution and department, and the title of your project may be provided to the federal, provincial and academic institution funders of the Accelerate program, to:
   a. Enable Mitacs to report on funding contract commitments; and
   b. Allow the funders to evaluate the program.

   Note that all Canadian provincial and federal governments, and academic institutions, are bound by privacy legislation and are therefore bound to keep your personal information confidential.

   Additional information, such as passport numbers and dates of birth, may be provided to the international funders of the program (if applicable), for adjudication and reporting purposes.
6. Your name, contact information, and other personal information as required may be provided to the academic institution(s) participating in the internship to enable the academic institution(s) to manage the award, to sign off on the pre-departure form (if applicable), and for reporting purposes.

I, the undersigned, do hereby give CONSENT to the use and disclosure of the information contained in my application for the purposes as described above.

_____	_____	_____
Intern Name	Signature	Date

Appendix B - Drop Down - Options

Please delete if not applicable

Please refer to the drop down of the section, and type the corresponding answer on the space provided.

1.5. Academic discipline:

- Business
- **Computer Science X**
- Earth Sciences
- Engineering
- Life Sciences
- Mathematical
- Sciences Social Sciences, Arts & Humanities
- Physical Sciences

1.6. Project priority sectors:

- Indigenous Affairs
- Advanced Manufacturing
- Aerospace
- Agriculture & Food
- Aquaculture & Fishing
- Automotive
- Biotechnology
- Clean Technology
- Commercial Services
- Construction
- Education
- Energy & Utilities
- Entertainment & Media
- Environmental Science & Technology
- **Finance & Insurance X**
- Forestry
- Green/Alternative Energy
- Health and Related Sciences & Technology
- Information & Communications Technology
- Life Sciences (not health)
- Manufacturing & Construction
- Mining
- Nanotechnology
- Natural Gas
- Natural Resources
- New & Digital Media
- Ocean Tech
- Oil & Gas
- Pharmaceuticals
- Public Service, Policy, & Governance
- Sustainability & the Environment
- Technology
- Tourism
- Transportation
- Water
- Other (please describe)

1.7. List of Participants:

Partner Legal Status:

- **For Profit Private Corporation X**
- Crown Corporation
- Not for Profit Canadian Corporation

4.3. Partner organization in Canada:

Partner size (No. employees):

- 1 to 49
- 50 to 99
- 100 to 499
- **500 and higher X**

Legal status:

- **For Profit Canadian Private Corporation X**
- Crown Corporation
- Not for Profit Canadian Corporation

If NFP:

- Charitable Organizations
- Economic Development Organizations
- Health Organizations
- Industry Associations
- Social Welfare Organizations
- Other

First time collaboration with academic institution?

- **Yes X**
- no

4.4. Partner organization abroad:

Partner size (No. employees):

- 1 to 49
- 50 to 99
- 100 to 499
- 500 and higher

Legal status:

- For Profit Private Corporation
- Crown Corporation

First time collaboration with academic institution?

- yes
- no

4.5 Intern(s) identified:

4.5.1. Intern information:

Citizenship:

- Canadian:
- Canadian Permanent Resident:
- **Foreign**: **X**

Gender

- Female
- **Male X**
- Other gender identity

Internship units outside of intern's home country?

- yes
- **no X**

4.6.1. TBD

Internship units outside of intern's home country?

- yes
- **no X**