Claims categorization using Artificial Intelligence: a proof of concept

Two-Sentence Overview

The goal of this project is to develop an **automatic claims categorization module** for openIMIS based on state-of-the-art Artificial Intelligence (AI) algorithms, standards, and methodologies which will drastically reduce the manpower, resources and time required to review a reimbursement claim. As a contribution towards achieving Universal Health Coverage, the Swiss Tropical and Public Health Institute (Swiss TPH) designed and developed the health insurance software 'openIMIS'. Other partners joined later such as the IT firm SolDevelo for specific work areas, thus bringing together state of the art Public Health and Software development expertise.

High-Level Budget Summary

	Work Package 1 Research Phase	**Work Package 2 Development Phase**	**Work Package 3 Testing Phase**	**Total Cost (USD)**
Total Project Costs	$ 108,135.00	$ 44,900.00	$ 24,725.00	**$ 177,760.00**

Executive Summary

This project aims to develop an Artificial Intelligence (AI) based claims categorization prototype application to automatically update the claim's status to accepted, rejected or to be further analyzed by a medical expert. The process will be divided into three phases:

- Research phase: Swiss TPH will work closely with GIZ Nepal to undertake the research and development of the AI algorithm for claims categorization based on anonymized openIMIS claim data and associated entities (insuree, health facility, diagnostics, medical items, and services). It will be crucial to have access to a database with already categorized digitized claims (by a Medical Officer) and to identify the key input variables to be processed by the AI algorithms. The overall objective of the AI component is to achieve claims categorization performance similar to the human expert results. Several classification methods (supervised and unsupervised) will be considered to fit the specific AI model to be elaborated. To make the solution available for different contexts and insurance entities, HL7 FHIR will be used for the input and output data format of the AI model.
- Development phase: SolDevelo will develop an openIMIS module that will integrate the AI algorithm and will create the requisite links and transitions for the module activation. Moreover, an extension of the Claim module will be developed to allow the Medical Officer to check the quality of the AI categorization results and adjust, if necessary, thus improving more the AI categorization model.
- Testing phase: Swiss TPH and GIZ Nepal will organize a workshop in Nepal and run the AI module in real case scenarios to validate the research and development phases.

Building on solid implementation and software maintenance expertise over the past 7 years, we are currently extending the partnership to Nepal Health Insurance Board/GIZ Nepal, who is an existing

openIMIS implementer for the Informal Sector that can already make categorized claims data available. With this background, we are confident that the automatic claims categorization module can be built and validated in the proposed time frame. The Digital Square investment would allow us to realize the automated (and AI-enhanced) claims categorization that will add substantial benefit to the health insurance system community.

Consortium Team

Swiss Tropical and Public Health Institute (prime organization)

Swiss TPH is a leading institute in global health with a particular focus on low- and middle-income countries with a staff strength of over 850 staff from 80 different nations, currently active in 300 projects across 100 countries.

Swiss TPH will provide technical project management, expertise on health financing, openIMIS, and AI algorithm development, drafting of business and technical specifications, supporting the system and architecture design.

Swiss TPH's relevant experience includes involvement in the design and implementation of the Insurance Management Information System (which is the genesis of the openIMIS Initiative) since its inception in Tanzania and has supported its implementation in a number of countries. Swiss TPH is currently implementing two projects at scale for the deployment of insurance schemes through openIMIS, in Tanzania and Cameroon, and two openIMIS pilots in Chad and Democratic Republic of Congo. In addition, Swiss TPH is actively involved in the development of openIMIS as part of the Implementers and Developers Committees of the openIMIS Initiative. Further, Swiss TPH is also implementing projects with AI-based on supervised machine learning to improve Clinical Decision Support Systems.

Qualifications of key members of the proposed project team:

- Dragos Dobre:
    - IT System Architect (PhD. in Automatics and Computer Science, MSc. in System Engineering) at Swiss TPH
    - Management of software life cycle (from specification to development and deployment)
    - Design, development, and maintenance of open-source applications
    - openIMIS design, development and implementation experience since 2018 in implementation sites of openIMIS - Tanzania, DRC, and Chad
    - Project Coordinator experience across international teams for GIZ openIMIS mandate
    - OMG-Certified Systems Modeling Professional™
- Siddharth Srivastava:
    - Health Financing Specialist (MSc. in Operational Research) at Swiss TPH
    - Over 10 years of experience in health insurance projects in Lower Middle-Income Countries (LMICs: India, Nepal, Bangladesh, Cambodia, Cameroon, Tanzania, Kenya, Malawi; backstopping roles in Chad and DRC)
    - Insurance Information systems design (capturing and documenting user requirements) and implementation (including capacity building) experience
    - IMIS/openIMIS design and implementation experience since 2013 in all implementation sites of openIMIS - Tanzania, Cameroon, Nepal, DRC and Chad
    - Project Manager/Project Coordinator experience across national teams for GIZ openIMIS mandates and insurance projects in Nepal, Cameroon, and Kenya

- Simona Dobre:
    - Data scientist (PhD. in Automatic Control and Signal Processing, specialized in modeling, identification and data analysis)
    - Over 10 years of experience in data analysis in interdisciplinary domains
    - Project Manager/Project Coordinator experience across international teams
    - Machine Learning and Deep Learning certification

SolDevelo

SolDevelo is a dynamic IT company founded in 2009 with over 80 employees and focuses on delivering high-quality software and innovative solutions.

SolDevelo will be responsible for the software integration of the AI module with openIMIS.

SolDevelo is currently involved in several openIMIS projects, including HL7 FHIR module development, openIMIS integration with OpenMRS project, maintenance and support project, and enhancing the security of the Microsoft solution. SolDevelo has been involved in many opportunities that required skill sets relevant to this particular project, especially through opportunities like OpenMRS (core contributors), HL7 FHIR implementation (OpenMRS Sync 2.0 module), nationwide micro-service based implementations (OpenLMIS), nationwide OpenHIE architecture based implementations (National Health Infrastructure project with such components like OpenELIS, DHIS2, OpenMRS and many other HIE compatible applications, health standards-based workflows for the Client Registry, Facility Registry, Health Management Information System, Shared Health Record, and Interoperability Layer).

Qualifications of key members of the proposed project team:

- Kamil Madej
    - Senior-level Java Developer/Team Leader (BSc. Engineering) at SolDevelo
    - Working in international teams for various projects/clients, like:
        - openIMIS
        - OpenMRS
        - MOTECH
        - Terre des hommes
        - Connect for Life
    - Performing code review
    - Creating high-level designs using tools for wireframing
    - Leading several frontend and backend development teams

Nepal Health Insurance Board / GIZ Nepal

Nepal Health Insurance Board is the implementer of openIMIS in Nepal from 2016.

Together with GIZ Nepal, they will be responsible for the appropriation of categorized claim data, the validation of the anonymized data set for AI analytics and the testing of the openIMIS AI module developed under this project.

Background or Problem Statement

Substantial manpower, time and resources are deployed in the process of claims management for cost refunds or claim audits. Considering the respective insurer policies and regulations, this process results in a) a payment of the claim, b) (partial) rejection of the demand or c) further analysis by a Medical Officer.

Currently, static validation rules based on insurance product configuration are implemented in openIMIS. They are 'hardcoded' in the system and applied to submitted claims. However, these validation rules only allow claims to be accepted or rejected and require the subsequent review by a professional Medical Officer.

For example, the openIMIS implementation in Nepal receives up to 7,000 claims per day. From all these claims, the team composed of five Medical Officers are able to review only 1,000 claims. This pressure of work can increase the risk factor for abuse, and perhaps fraud, in healthcare.

Once the database of categorized claims is available, the automated claims categorization (based on AI) enables the encoding of the Medical Officer's knowledge into a model that can automatically check future claims, and thus allowing the Medical Officer to concentrate on those claims that really need to be reviewed such as inconsistent, erroneous and identified as fraud/abuse claims.

For the AI algorithm development, several methods will be considered [1,2,3,4]:

- Supervised methods will attempt to discover relationships between claim entities (e.g. price of a drug or service, the age, and sex of the patient, the diagnosis, etc.) and the output variable. Methods such as neural networks, decision trees, Support Vector Machine are known to be applied in the insurance sector.

- Unsupervised learning methods will allow to assess one claim attribute in relation to other claims to determine the similarities between them and thus will be able to distinguish anomaly records or group of similar records using methods like 'anomaly detection', 'association rules' or 'clustering'.

The work will take place in different places (Nepal, Switzerland, Poland) and will have a common test environment in Nepal infrastructure. It is an exploratory project that will improve openIMIS and increase adherence to new implementation sites.

Digital Health Technologies

Nowadays, AI algorithms can address decision-making and detection tasks related to different health issues (diabetes, health problems, asthma, etc.) and are highly favorable to patient engagement. Furthermore, it can improve access to care by enhancing the dynamic communication between patients and physicians. In that direction, the automatic process of claim management could improve access to care, by reducing the payment delay.

The aim of this project is to improve the open-source Insurance Management Information System (openIMIS) digital tool with the use of AI and health-related standards.

openIMIS is a comprehensive system for managing a health insurance scheme (enrollment, renewal, claims management, feedback, reporting). We will focus on the claim review process and will do the development based on the new modular architecture developed in Python with the Django framework for the back end and Javascript with the React framework for the front end.

The new developments will integrate the AI-based algorithm (will be defined in the research phase) which will classify digital claims, recorded in openIMIS. The AI algorithm will be developed in Python and will be able to build, train and validate models.

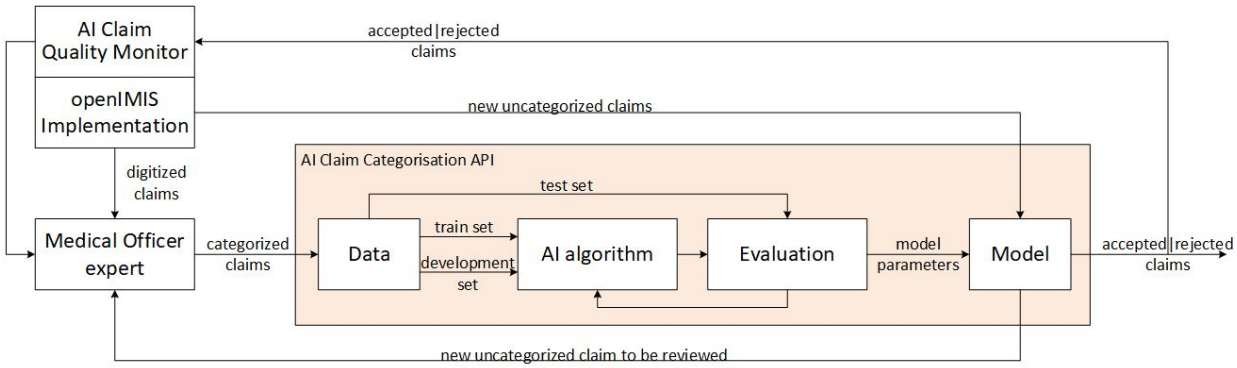
Fast Healthcare Interoperability Resources (FHIR) is a draft standard describing data formats and elements (known as "resources") and an application programming interface (API) for exchanging electronic health records. The standard was created by the Health Level Seven International (HL7) health-care standards organization. We will use this standard for the API communication protocol and as

the internal data structure, thus developing an interoperable solution ready to be integrated into standardized health architectures (e.g. OpenHIE).

Lastly, we will follow the Principles for Digital Development and involve end-users in the specification, development, and testing of the proposed solution.

Use Cases and User Stories

The following use case will be covered by the developments for this proposal. This use case will be valid for any insurance scheme wanting to implement AI-based claim categorization and describes the steps, entities, and data flows for a successful implementation. For the research and development of this project, we will use the openIMIS entities and their attributes mapped to the FHIR data format (version to be defined together with the community).



Process steps:

1. Once the openIMIS platform is configured based on the scheme-specific implementation, claims data will start to be processed, through the openIMIS internal claim adjudication process.
2. A Medical Officer expert will manually categorize (review) the digitized claims as accepted or rejected.
3. When sufficient local claims have been categorized, the openIMIS AI module will be activated and configured (choice of algorithm, based on algorithm selection from this project's research phase, and attributes) by a data scientist (from the local implementation). He/she will start to prepare the input data (openIMIS to FHIR transformation, split the data into training, development and test sets) to feed into the AI module for training and evaluation. This will result in assessment parameters (output) specific to the implementation needs.
4. The resulting adapted AI model will be then used to categorize new digitized claims to accepted, rejected and to be reviewed by a Medical Officer expert. Moreover, these manually reviewed claims will then be fed back into the system and improve the new AI model (steps 2 and 3).
5. Using a subset of the AI categorized claim, a Medical Officer will validate the quality of the results (check for false positive and negative results) and manually review claims with errors that will be fed back into the system and improve the new AI model (steps 2 and 3).

Objectives and Activities

To achieve the described objectives, the activities will be grouped into three work packages.

Work package 1: Specification and development of the Artificial Intelligence algorithm (research phase)

Objective 1.1: Data gathering and preparation

Activity 1.1.1: Required data field selection

Discussions are mandatory between partners to understand the claim review process, openIMIS existing database, and necessary entry models and attributes necessary to feed to the AI algorithm. Exploration of the quality of the categorized digital claim database, to avoid duplicates, incorrect/ inconsistent/missing values. We will also review the mapping between openIMIS and FHIR.

Output: AI input data model structure

Activity 1.1.2: Claims data anonymization

Based on the required data and on the established data privacy standards, we will develop a script (code) that will anonymize the implementer's already categorized claims data being used as the input data during the AI algorithm development. Moreover, this data will be transformed to FHIR format.

Output: anonymization script and anonymized AI input data

Activity 1.1.3: Data preparation

Visualization of the anonymized database, normalization, randomization and splitting the database into train/development/test sets.

Output: normalized input data sets

Objective 1.2: Implementation of the AI algorithm

Activity 1.2.1: AI algorithm selection

Several algorithms specific to health insurance applications are documented in the literature and are relevant for the proposed goal. Unsupervised and supervised methods can be applied and the choice will depend on the existing database and specific objectives. Several models can be selected to compare their performances based on a selected evaluation metric. This step includes the definition of the output model, that will be mapped to FHIR data structure as the output of the AI module.

Output: AI methods, model outputs, and evaluation metric

Activity 1.2.2: Building the AI algorithm

This step will be dedicated to the development of the AI algorithm (based on the selected methods, model outputs, and evaluation metric), train the model (estimation of the model parameters based on the training data set), tuning the hyperparameters (on the development data set) and make predictions (on the test data set). A comparison of the performance obtained on the train/development/test sets will allow deciding if there are improvements to be made (in terms of dimensions of the model, hyperparameters values, optimization algorithms, etc.).

Output: AI code and model parameters

Work package 2: openIMIS AI module development

(development phase)

Objective 2.1: Specification of AI algorithm integration

Activity 2.1.1: Claim adjudication process update

The AI algorithm and model will be integrated with the openIMIS 'Claim Module' and will replace the manual review process. During this activity, we will define the new openIMIS Claim adjudication process (including the automated claim categorization).

Output: AI-based Claim adjudication process

Activity 2.1.2: openIMIS AI module specification

Specification of the openIMIS AI code integration will be developed: the database structure extension, the openIMIS AI module specification, the events that will activate the AI code, etc.

Output: AI module specification

Objective 2.2: openIMIS AI module development

Activity 2.2.1: openIMIS AI module development

Based on the AI module specification, a new module will be implemented into the new openIMIS modular architecture based on Python with Django and JavaScript with React software development frameworks.

Output: openIMIS AI module

Activity 2.2.2: openIMIS AI module validation

The new openIMIS AI module will be validated on new claims with Medical Officers involved in the research phase.

Output: validated openIMIS AI module (code and model parameters)

Objective 2.3: openIMIS AI Claim Quality Monitor module

Activity 2.3.1: AI Claim Quality Monitor module specification

Based on the openIMIS Claim module, we will specify the AI Claim Quality Monitor module as a new module or as an extension of the existing module.

Output: AI Claim Quality Monitor specification

Activity 2.3.2: AI Claim Quality Monitor module development

Based on the provided specification, a new module will be implemented into the new openIMIS modular architecture based on Python with Django and JavaScript with React software development frameworks.

Output: AI Claim Quality Monitor module

Activity 2.3.3: AI Claim Quality Monitor module validation

The new openIMIS AI module will be validated on new claims with Medical Officers involved in the research phase.

Output: Validated AI Claim Quality Monitor

Work package 3: openIMIS AI module implementation integration
(testing phase)

Objective 3.1: User Acceptance Testing (UAT) of the AI module

Activity 3.1.1: Installation of AI-based openIMIS

We will install the AI-based openIMIS implementation in the Implementer's testing environment and connect to the Implementer's testing database. The initial parameters (output from Activity 2.2.2) for the AI categorization model will be configured in the AI module.
Output: AI-based openIMIS testing environment

Activity 3.1.2: Organisation of the UAT

The UAT process will be specified (testing plans) and the required resources will be defined. Any reported issue will be solved.
Output: UAT test plans and reports

In all these phases, Swiss TPH will closely monitor the advancement of the project and report periodically to Digital Square and to the openIMIS Initiative.

Community Feedback

The topic of Artificial Intelligence is still underused by digital development and open source communities. We want to change that by providing easy-accessible regular reports from our research phase. Our experiences and findings should help other initiatives to start working with this technology. Also, through our contact email and comment section, we would be able to hear the opinion of others on our work and eventually incorporate some of their feedback into our project. We would also like to create a case study at the end of the project, that would be published on various blogs and websites for digital development specialists (like, for example, ICTWorks).

Schedule

The following is a high-level work plan.

Activity	Team	Month								
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
		1	2	3	4	5	6	7	8	9
1.1.1. Required data fields selection	Swiss TPH	x	x							
1.1.2. Claims data anonymization	Swiss TPH		x							
1.1.3. Data preparation	Swiss TPH			x						
1.2.1. AI algorithm selection	Swiss TPH			x						
1.2.2. Building the AI algorithm	Swiss TPH				x	x	x			
2.1.1. Claim adjudication process update	Swiss TPH							x		

2.1.2. openIMIS AI module specification	Swiss TPH							x		
2.2.1. openIMIS AI module development	SolDevelo							x	x	
2.2.2. openIMIS AI module validation	Swiss TPH								x	
2.3.1 AI Claim Quality Monitor module specification	Swiss TPH							x		
2.3.2 AI Claim Quality Monitor module development	SolDevelo								x	
2.3.3 AI Claim Quality Monitor module validation	Swiss TPH								x	
3.1.1. Installation of AI-based openIMIS	SolDevelo								x	
3.1.2. Organisation of the UAT	GIZ Nepal									x

Deliverables

Deliverable	**Month Due**
AI input data model structure	January 2020
Anonymization script and anonymized AI input data	January 2020
Normalized input data sets	February 2020
AI methods, model outputs, and evaluation metric	February 2020
AI code and model parameters	May 2020
AI-based Claim adjudication process	June 2020
AI module specification	June 2020
openIMIS AI module	July 2020
Validated openIMIS AI module (code and model parameters)	July 2020
AI Claim Quality Monitor module specification	June 2020
AI Claim Quality Monitor module	July 2020
Validated AI Claim Quality Monitor module	July 2020

AI-based openIMIS testing environment	July 2020
UAT test plans and reports	August 2020

Global Good Maturity Model Assessment

Please review the updated link.

References

[1] Li, J., Huang, KY., Jin, J. and Shi, J. A survey on statistical methods for health care fraud detection, Health Care Manage Science, 11 (3), pp. 275-287, 2008
[2] Ortega, P.A., Figueroa, C.J., and Ruz, G.A. A medical claim fraud/abuse detection system based on data mining: A case study in Chile, DMIN'06, The 2006 International Conference on Data Mining, Las Vegas, Nevada, USA, June 26-29, pp. 224-231, 2006
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