Digitalization of the Healthcare Industry by Implementing Robotic Process Automation and Machine Learning Solutions

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Summary:

The main challenge in healthcare industry is managing and processing the information related to patients. Healthcare workers are spending a lot of time in solving rule-based and manual tasks across multiple systems. These tasks include enrollment application, scheduling appointments, billing, clinical data extraction etc. Due to this, services to patients are slower leading to low productivity and longer waiting times. A RPA application can automate such type of time consuming tasks and make employees available for patient care.

The main objectives of the thesis are to identify the tedious tasks at the hospital and evaluate them for RPA potential to develop RPA application where a software robot can automatically perform the task faster than the employee to increase the workflow efficiency. Various RPA tools are evaluated for developing the automation process and community edition of UiPath is chosen as the most suitable RPA tool for our purpose. Using UiPath, tasks such as 1) reading patient medical form, 2) entering patient details into patient registration software, and 3) finding diagnosis related keywords in epicrisis document are automated.

Preface

Digital tools and ICT have huge potential to improve the quality of services provided by healthcare, enable employees to have better working environment and improve the quality of service. For that purpose, robotic process automation (RPA) technology can be used to automate high volume manual tasks that are rule-based and repetitive. To that end, this thesis focuses on identifying such tasks and providing a proof-of-concept for RPA in healthcare industry.

I would like to thank my supervisors Hans-Petter Halvorsen, USN, Porsgrunn and Odd Nærum, Sykehuset Telemark (STHF), Skien for their guidance and advice during this project.

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Haritha Pathuri

Contents

Nomenclature

AI – Artificial Intelligence

API – Application Programming Interface

BLOB – Binary Large Object

ECG – Electrocardiogram

EHR – Electronic Health Record

EPIC EMR – Cloud-based EHR

GDPR – General Data Protection Regulation

GP – General practitioner

GUI – Graphical User interface

HR – Human Resource

ICT – Information & Communication Technology

IDM – Identity and Management System

ML – Machine Learning

NHR – National Health Registry

NHS – National Health Service

NPR – National Population Registry

OCR – Optical Character Recognition

QV – Quick View

RPA – Robotic Process Automation

SQL – Structured Query Language

WHO – World Health Organization

1 Introduction

Healthcare is an important pillar of the society. Hospitals are key to provide quality healthcare both curative and preventive care. Hence, there is a necessity to integrate digital technology in the healthcare industry to improve patient care and to increase the workflow efficiency. Digital tools and ICT have immense potential to improve the quality of services provided by healthcare and help the employees to have efficient and better working environment. Robotic Process Automation technology uses software tools to automate high volume tasks performed by the human that are rule-based and repetitive. This technology consists of software robots that can imitate the human activity by interacting with the other software applications to perform the required task. These robots can perform data extraction and insertion to database, fill the forms, login to applications, read document among many other tasks.

The main challenge in healthcare industry is managing and processing the information related to patients. Healthcare workers are spending a lot of time in performing rule-based and manual tasks across multiple systems. These tasks include enrollment application, scheduling appointments, billing, clinical data extraction etc. Due to this, services to patients will be slower leading to low productivity and longer waiting times. An RPA application can automate such type of time-consuming tasks and make employees available for patient care.

1.1 Contribution

The main objective of the thesis is to identify the tedious tasks at the hospital and evaluate them for RPA potential to develop RPA application where a software robot can automatically perform the task faster than the employee to increase the workflow efficiency. UiPath tool has been chosen for implementing the RPA application. Also, the machine learning algorithms will be evaluated to extend the use of RPA application. As RPA applications cannot be developed for every work process in the healthcare sector, we must identify the tasks that are suitable for the RPA implementation. Healthcare employees at STHF are interviewed with a questionnaire [appendix B] to identify the time-consuming and rule-based manual tasks. After analyzing the interview data, few use cases are identified which have the scope for RPA implementation. The identified use cases are 1) reading the patient's health record for appointment scheduling, 2) adding patient medication data to the epicrisis document, 3) searching for diagnosis keywords in epicrisis document, 4) sending diagnosis codes to NPR, 5) preparing the medication dose for patients in MetaVision, 6) entering cancer patient data to NHR.

UiPath tool is chosen for developing RPA application as it is user-friendly, easy to implement and has free community edition for developing RPA application for individuals. This tool comes with studio, robot and orchestrator where studio is a visual designer used to create the workflow of the process and publish them to the orchestrator. The robot is used to execute the processes and the orchestrator is used for monitoring and scheduling the robots to run the deployed automation processes on various machines. After analyzing the use cases that have potential for RPA application, they are divided into three categories of automation based on the workflow sequence of the tasks, which are listed below:

1. Data entry automation
2. Document reading automation
3. Keyword search automation

Implementation of actual use cases 1 to 6 requires access to restricted softwares and registries DIPS, NHR, NPR, and MetaVision. To overcome this problem, a test registration software with minimal features is developed as simple representative for DIPS using C#. However, such a workaround for NHR, NPR, and MetaVision is not possible. Hence, in this thesis only equivalent of use cases 1 to 3 are considered for implementation. The selected use cases are 1) reading patient medical form, 2) entering patient details into patient registration software, and 3) finding diagnosis related keywords in the epicrisis document.

The automation processes for the use cases 1 to 3 are developed in UiPath studio in the local computer and published to the orchestrator. Figure 1.1 shows the overview of developing and publishing automation processes.
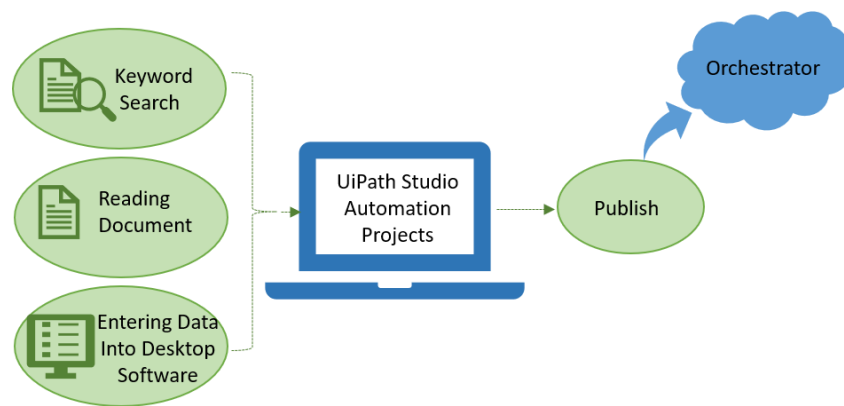
Figure 1.1: Overview of developing and publishing automation processes

 A robot is assigned in the orchestrator to execute these automated processes in the local computer. These automated processes can also be executed in different machines by providing machine name and assigning a robot to each machine in the orchestrator. Figure 1.2 shows a graphical overview of execution of automation processes.
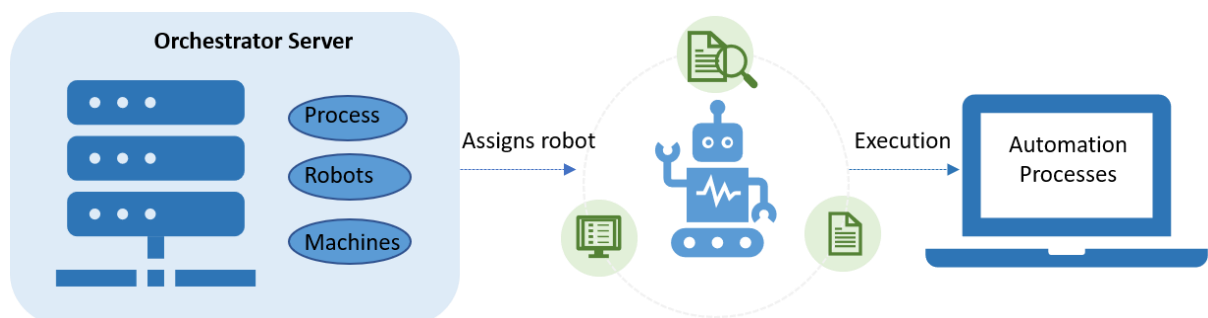
Figure 1.2: Overview of execution of automation processes by the robot

1.2 Thesis organization

Chapter 2 describes the importance of healthcare industry and the necessity of including digitalization in the healthcare industry.

Chapter 3 introduces RPA and describes the various phases of RPA life cycle. It also describes the most popular RPA tools along with a comparison between them. Comparison of RPA tools with the general-purpose programming language is also discussed in this chapter.

Chapter 4 presents the general RPA applications, RPA applications in healthcare industry and the advantages of RPA and implemented use cases using RPA in COVID-19 epidemic.

Chapter 5 describes the UiPath studio, UiPath components, UiPath activities, robot and the orchestrator.

Chapter 6 presents the interview of healthcare of employees at STHF, analysis of the data and identification of the use cases that are suitable for RPA application.

Chapter 7 describes the design and development of RPA application for the three use cases identified at STHF. It also presents patient registration software that is developed using C# and used for testing one of the use cases.

Chapter 8 describes the deployment and execution of developed RPA applications using UiPath robot and orchestrator.

Chapter 9 discusses the GDPR, data security methods in automation, and RPA with Machine Learning solutions.

Chapter 10 provides the conclusion with brief description on how the objectives of this thesis are achieved and discusses the scope for future work.

2 Background

2.1 Healthcare industry

Healthcare industry is one of the most important pillars of modern society both in terms of human life and economy. Modern advances in healthcare has reduced child mortality, improved lifespan, reduced pandemics, enhanced quality of living among many other benefits. Health care is also significant driver of economy due to spending by consumers and state. Globally, around 32 million people are directly employed by healthcare industry according to WHO [1] and accounts for 10% of GDP expenditure in Norway and average of 8.5% in OECD countries [2]. Healthcare industry consists of different but related groups that provide wide range of services. The main constituents are (1) health care service providers and facilities which include hospitals, laboratories, nursing homes, (2) manufacturer of healthcare equipment which develop hospital supplies such as beds, ambulances etc, medical devices such as Pacemakers, X-rays, MRIs, etc, and (3) producers of consumables such pharmaceuticals and medicines.

However, healthcare industry faces many challenges such as increase in aging population, rise of chronic and lifestyle diseases, reduction in infrastructure investments, higher labor costs, shortage of healthcare professionals. Health care industry is struggling around the world to maintain financial sustainability in this changing environment. For example, the NHS health trust had a deficit of 551 million GBP in 2018-19. It is becoming increasingly difficult to efficiently run universal health care systems due their large size, budget, and complex operations. Healthcare has also become increasingly consumer oriented with demands for higher engagement and empowerment. The patients have become more active participants and expect convenience, access to data, and personalized service. The emphasis is more on preventive approaches compared and demand faster and dedicated service. Hence, given the behavioral changes and demanding environment, a different approach is necessary to handle the challenges faced by healthcare industry. Digitalization plays an important role in achieving healthcare goals and maintain the positive change brought by healthcare industry.

2.2 Digitalization

Digitalization is the process of changing the business activities and operations to improve efficiency, quality of service, value, and revenue by using digital technologies such as automation, cloud computing, artificial intelligence, web solutions. Digitalization and digital transformation offer huge potential to reduce the problems faced by the healthcare industry. It has scope to address multiple issues simultaneously and help the industry on multiple fronts. Some of the key digital tools that can aid healthcare are digital patient records, cloud computing, AI and machine learning, big-data analysis, robotics, internet-of-things, automation, and communication infrastructure.

Digitization can make patient data easily accessible and portable. Medical history of patient can be stored digitally with access provided to approved people. The patient no longer needs to carry their historical health information when consulting healthcare professionals. The service providers can access such data anywhere which makes treatment easier during

emergencies. Cloud computing provide reliability and access to data processing and communication than on-campus computing. It also offers mobility where data of a particular patient can easily and securely accessed anywhere on demand.

Digital tools can help focus on prevention and not just treatment. Internet-of-things containing a network of medical sensors, software applications, cloud computing, and actuators can continuously monitor individual as well as public health and take necessary activities to improve health outcomes. Using a connected infrastructure of data computing, decision making, and software applications, these data can be analyzed by software and cloud to monitor health conditions. For example, heart rate and ECG sensors in smart watches and fitness devices can monitor important cardiac signals and can alert medical personnel in the event of emergencies. Fall detection sensors can automatically help elderly to receive attention during emergencies.

Big data analysis can process large data acquired from different sources to extract relevant information such correlation, efficacy, trends and statistics. It also provides rich capabilities for data visualization that help communication and decision-making. Further, machine learning and AI can exploit the acquired data to help healthcare professionals for diagnosis, prescription, and treatment. For example, AI and ML based algorithms have superior accuracy in analyzing medical images. Many pharmaceutical companies employ AI algorithms to find new drugs and treatments cutting down the development time and releasing medicines faster to the public.

Robotics can help not only to perform routines tasks in healthcare industry such as imaging, patient care, mobility, but also advanced activities such as precision surgery and complex testing procedures.

2.3 Machine learning

Machine learning is a field concerned with acquiring knowledge, understanding the underlying phenomena of interest, and modeling the phenomena using the measurement data, historical data, and empirical data, which are together termed as training data. This knowledge can be further used for making predictions and analysis of newly acquired data. Machine learning algorithms form a subset of broader artificial intelligence. Few examples of machine algorithms are automatic conversion of handwriting to text, self-driving cars, driver assist technologies that can follow traffic, stop for pedestrians, automatic tagging of faces in pictures and videos. The three main aspects of machine learning are data preparation, machine learning algorithms, and predication and data analysis. The data preparation involves formatting the acquired data that is compatible with the machine learning algorithms. Some of the formatting steps are selecting the data samples that capture the phenomena and discarding irrelevant data, aggregating data obtained from different sources, cleaning up incomplete or erroneous data entries, pre-processing the data to match the requirements of the learning algorithms.

The machine learning algorithms are methods or procedures that take training data as input and obtain a mathematical model or description of the underlying phenomena. The algorithms can be classified into supervised, semi-supervised, unsupervised, and reinforcement learning. Supervised learning builds the models uses a known data input and its corresponding output, which are called as labels, to develop a model or relationship the input and output. Common supervised learning algorithms are regression methods, support vector machines, neural networks. In unsupervised learning the algorithms obtain the underlying pattern using only

input data with no labeled responses that corresponds to the input. Examples of such algorithms are clustering methods, Markov models, neural networks. Semi-supervised learning methods uses concepts from both supervised and un-supervised learning by relying on a minimum training data with labels and huge amount of data without any labels for the training process. In reinforcement learning algorithms, the model interacts with the environment, choses certain actions, and consider the outcome. This helps the model to evaluate the outcome of its actions for a given state of the environment using a predefined reward function. The interactive process helps the model understand the underlying process.

3 Robotic Process Automation

3.1 Introduction

Business and industries loss significant time and resources due to workers spending time on redundant and repetitive tasks that can easily automated. RPA is a tool to automate various business process and repetitive tasks using software robots and limiting human intervention. This helps in reducing manual tasks, speed-up the activities, and allow employees to concentrate on providing better quality service. The software robots are programmed to execute tasks continuously with no error and replicate human actions. RPA automates predefined work tasks which are administrative in nature and performed very often. With RPA, the human resources can be used for critical task requiring human cognition and decision making. RPA comprises of four entities that jointly result in automating the tasks. These entities are 1) recorder that captures human actions, 2) designer that develops and maintain process workflow, 3) orchestrator that deploys and manages RPA in addition to coordinate different robots, and 4) robot that imitates human action by executing applications and managing data. The main advantages of RPA are

1. Cost-effectiveness: Developing and deploying software robots are one-time activities. These software robots can operate round-the-clock. This reduces the cost associated with completing tasks.
2. Resource optimization: With routine activities taken care by software robots, employees can concentrate on tasks that create more value.
3. Better business processes and customer experience: Robots can acquire lot of data while executing the process which can be used for analysis and refining business process. Further, they can understand customer preference and help them serve faster and round-the-clock.
4. Strict compliance: Due to lower errors, ability to easily track robot activities, and limited scope for manipulation, it is easy to enforce strict compliance and perform audit if necessary.

3.2 RPA lifecycle phases

There are six phases involved in developing and implementing automation process using RPA technology [3]. Figure 3.1 shows the phases of RPA lifecycle. Each phase is described below.
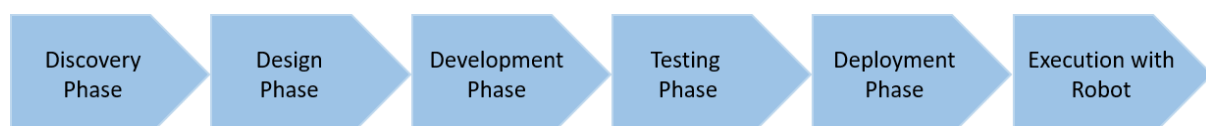

Figure 3.1: RPA lifecycle phases

1. Discovery phase: Since not all process cannot be automated using RPA technology, the first step in RPA lifecycle is to identify and analyze the task to decide whether the task

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can be automated or not. If the task can be automated, then the resources required to complete the automation must to be gathered.

2. Design phase: In this phase, the sequence of steps that the robot must perform to successfully complete the task is represented using a flow chart diagram.
3. Development phase: The steps identified in the design phase are implemented using RPA tool.
4. Testing phase: In this phase the developed automation process is tested by the developer before deploying the process to the robot for execution.
5. Deployment phase: After completing the testing of automated process, it can be deployed to orchestrator for execution on the machines.
6. Execution phase: The robot will execute the process after the deployment of the process.

3.3 RPA tools

RPA tool is a software that is used to create workflow of the tasks and uses robots to execute the created workflows. There are many RPA tools available in the market for developing the RPA applications such as UiPath, BluePrism, Automation Anywhere, Automai, WinAutomation, LINX, AutomationEdge. But the most popular tools are UiPath, BluePrism and Automation Anywhere based on the ease of usage, developer resources and community, and performance. These tools are described in detail in the subsequent sections followed by comparison between them.

3.3.1 UiPath

UiPath has visual development environment to automate repetitive tasks with drag and drop functionality. It mainly consists of UiPath studio, robot and orchestrator [4]. The workflow process will be created in studio and the robot will execute these processes. And the orchestrator is used to monitor and schedule the robots to execute the process on various computers. Three types of workflows designs are available in UiPath studio to develop automation processes. The user can decide the type of workflow sequence, flowchart or transactional business process depends on the necessity of the project. The activities needed for creating the workflows are visible in *activities* pane.

3.3.2 BluePrism

Blueprism software is another tool which can be utilized for automating manual, rule-based and repetitive tasks through a digital virtual workforce. The software enables to develop automation process workflows by using flowcharts in the visual development environment. The key components of the environment are object studio, digital workforce, and control room. The object studio is used to develop automation process using the drag-and-drop features offered by the user interface. The developed automation processes are executed by digital workforce and control room can be used for assigning the process to digital workers.

3.3.3 AutomationAnywhere

Automation anywhere is another popular RPA tool used to automate the monotonous tasks performed by the humans. It consists of three primary components to create the automatic process which are control room, bot creator and bot runner. The bot creators are used to develop bots, which are desktop applications. bot runners are used to execute these developed desktop applications whereas the control room is a web-based application to monitor the bot runners and assign the automation process to bot runners for excecution.

3.3.4 Comparison of popular RPA tools

Table 3.1 shows the comparison of UiPath, BluePrism and Automation Anywhere. Among these three tools UiPath is the most suitable for individuals due to the availability of free community edition and ease of developing automation projects. It also does not require knowledge of any compute programming.

Table 3.1: Comparison between most popular RPA tools.

Features	UiPath	BluePrism	Automation Anywhere
Architecture	Web-based orchestrator	Client-server building	Client-server based
Cognitive capability	Low capability	Low capability	Medium capability
Robots	Used for both front office and back office	Used for back office automation only	Used for both front office and back office
Macro recorder	Allows recording	No recoding	Allows recording
Process designer	Visual process designer	Visual process designer	Script based
Accessibility	Mobile and web browser	Application based	Application based
Prerequisites	Visual basic skills with little or no programming skills	Moderate level programming skills required	Beginner level programming skills required
Community version	Available	Not available	Available
Evaluation version	30days	Not available	45 days
Pricing	Effective, pleasant entry-level pricing	High cost	High cost

3.4 Comparison of RPA tools with general purpose programming languages

RPA is used to automate the repetitive tasks using robots whereas in traditional automation a programming language is used to automate the tasks by interacting with the API. Programming languages such as Python and Java are used in traditional automation. Python is a popular programming language with wide applications in automation for desktop applications and Python with Selenium is employed for web applications. To automate tasks using programming languages the developer must have coding skills whereas RPA is GUI based and code-free that allows developer to automate complex tasks in a very easy way by drag-and-drop activities using the visual designer. There are several advantages of RPA tool over traditional programming languages in automation in terms of ease of development, implementation, testing, and updating the existing automation project. A brief comparison of these approaches in terms of various parameter are given below.

1. Functioning: The sequence of instructions written using programming language will be executed to perform tasks automatically. In RPA the robot executes the process designed by the user.
2. Design time: Automation application using programming language requires more time when compared to using RPA tool.
3. Scalability: The user should understand the code written in the existing automation application for improving or expanding it to accomplish additional tasks. It is easier in RPA as flowcharts or sequences are used in visual designer for developing the process.
4. Execution: Various programming methods are needed to perform parallel execution of automation applications. In RPA, the robots can be scheduled to perform various tasks using UiPath robots or orchestrator.
5. Maintenance: RPA applications are easy to develop and maintain, even for people with no coding background.

4 RPA Applications

4.1 General applications

Since RPA can be designed according specific requirements, it can be used in wide range of sectors. For example, it can be used in 1) banking to validate application documents, process credit card transactions and insurance claims, communicate with customers, sorting records and emails, filling forms and data, 2) healthcare to maintain digital health records, update patient data, billing and insurance claim during discharge, 3) retail industry to track orders, update shipping details, manage and audit inventory, plan logistics, 4) IT to automate software installation and updates, data collection and logging, creating accounts and profiles. Figure 4.1 shows the general RPA applications.
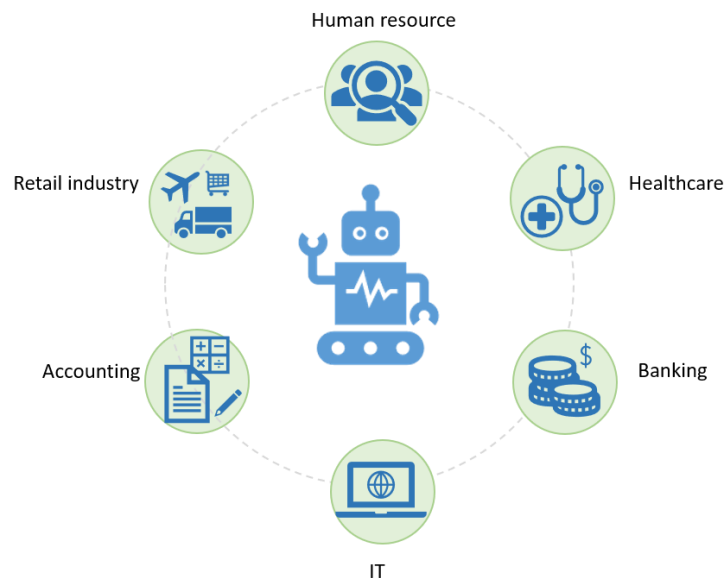

Figure 4.1: RPA applications in general

4.2 Healthcare applications

There are many benefits of using RPA in healthcare such as releasing the health worker from tedious and repetitive administrative tasks and make them available for patient care there by increasing the speed, quality and efficiency in providing health care to patients. It helps in converting manual tasks such as reading patient documents, scheduling of appointments, data extraction from clinical applications and lab systems etc to automated processes. Some of the use cases that are in use in Norwegian hospitals are discussed below.

4.2.1 Cancer registry by robot use case

Robbie vest is a robot that performs the registration job and saves time for the doctors at Haukeland University Hospital [5]. Since the doctor must spend time entering details of cancer

patients into three different applications such as DIPS, research database, and the cancer registry, the robot is deployed to take care of the registration corresponding to the cancer registry. The robots require only two minutes to extract necessary data from patient record and transmit it to cancer registry by logging into the applications as normal user.

4.2.2 Record birth weight of babies use case

Health Vest, Norway has implemented RPA for converting manual tasks to automated processes [6]. One of the automated process is to record the weight of babies and save the information in the medical records.

4.2.3 Data transmission use case

A robot is used at the Health Vest for sending or transmitting the epicrisis document to the patient's GP [7]. Epicrisis document is written by the doctor with a summary of diagnosis and the treatment done for the patient at the hospital.

4.2.4 Searching allergic reactions use case

An automatic process is developed at Sorlandet hospital for finding out the allergic reactions of patient by reading the patient medical records [8].

4.3 RPA's uses and advantages in COVID-19

During this COVID-19 pandemic, the roles and responsibilities of health workers have increased rapidly. It is highly difficult for them to schedule and manage large volume of test results with the existing staff at the hospitals. Hence, there is an immense potential for RPA implementation in this situation in the healthcare industry. Using RPA for COVID-19 can speed up the process of scheduling tests, providing faster lab test results and hiring large number of volunteers. This section describes the use cases that are implemented in health sectors and the use cases that have potential for implementation for assisting the healthcare sector in this crisis situation.

4.3.1 Administrative tasks use case

At Mater Misericordiae University Hospital in Dublin, UiPath robot is used to perform the basic administrative tasks that were done by nurses previously [9]. This made the nurses available for patients fighting with COVID-19.

4.3.2 Registration for testing use case

Cleveland Clinic, US has deployed a robot that uses the patient data to register for the COVID-19 testing [10]. This robot first checks the Epic EMR if the patient is registered already.

4.3.3 Reporting results use case

Nurses are spending more time on logging the COVID-19 test results into different systems need to report to infection and prevention control. The robot can be used to accomplish this task by logging to the systems [11].

4.3.4 Volume recruitment of volunteers use case

During this COVID-19, recruiting large number of volunteers involves more manual tasks. A robot can be used to for processing the applications and forward them to HR [12].

5 Introduction to UiPath

UiPath is one of the popular RPA tools in the market. This software tool has four types of trial packages available for download **Error! Reference source not found.**. It has community cloud, enterprise studio, enterprise cloud and enterprise server out of which the community cloud has free license available for individual use. This community edition of UiPath comes with studio, robot and orchestrator. This chapter describes the role of studio, robot and orchestrator in implementing the automation of workflows.

5.1 UiPath studio

UiPath studio has a visual designer for creating simple and complex automation workflows with pre-built activities for administrative and business IT tasks [13]. Additional activity packages can be installed in the studio from M*anage Packages* in the ribbon tab. Figure 5.1 shows the UiPath visual designer.
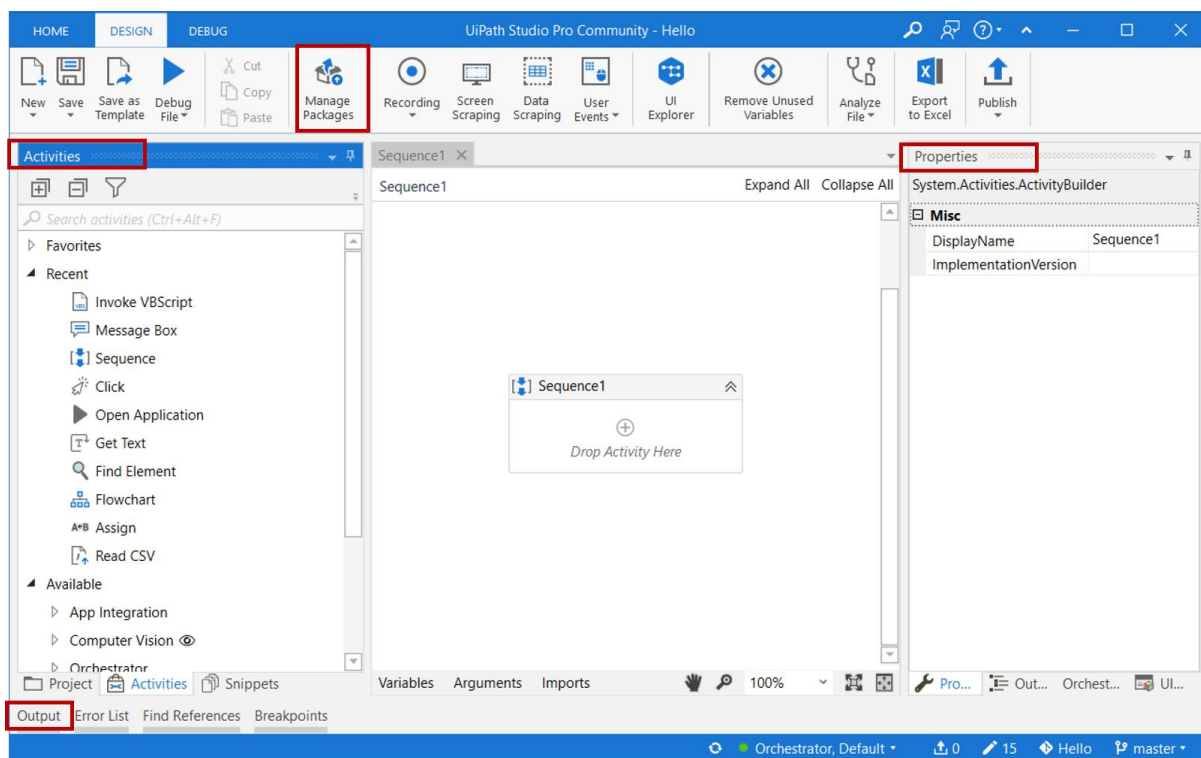

Figure 5.1: UiPath visual designer

UiPath studio has an option to create new project or new template with three options for project and various kinds of templates for creating a automation project. Figure 5.2 shows the types of project templates available in the UiPath studio.
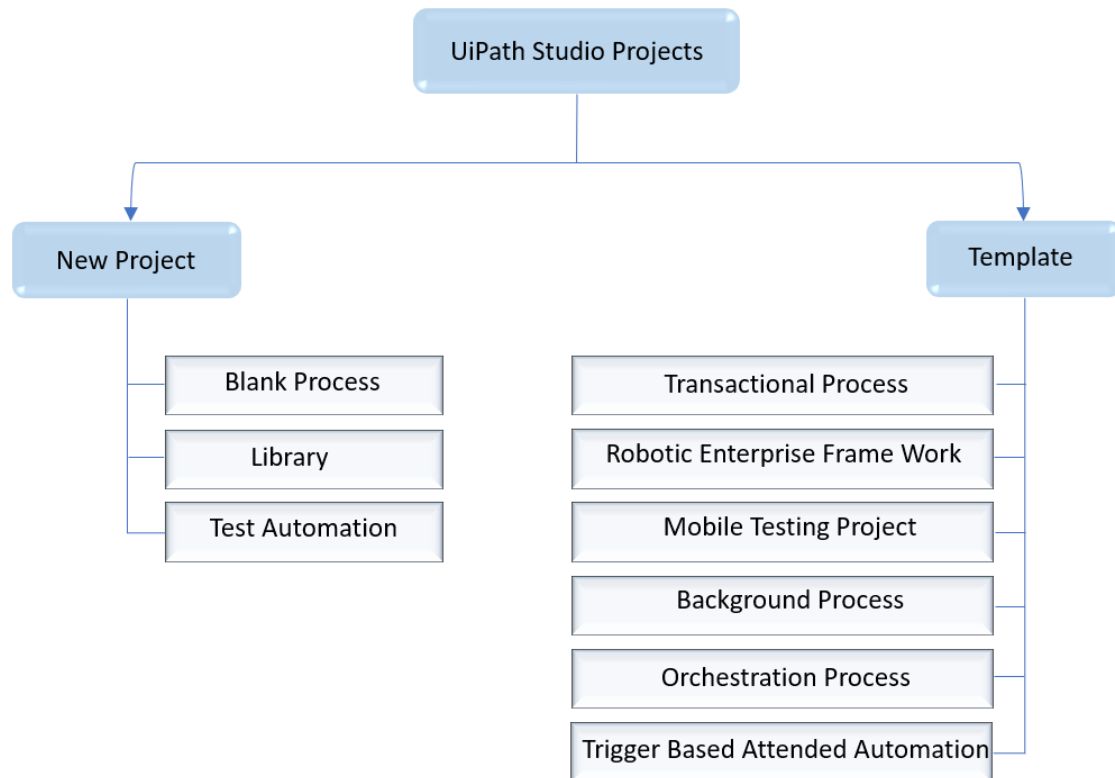
Figure 5.2: Types of project templates available in studio

A detailed description of the projects and templates available are given below:

1. Blank process: This project type is used to create blank automation project according to the user requirements.

2. Library: This project can be used to create a basic library in the studio. This can be done by creating reusable components and publishing them as library. Further, the library can be used in other automation projects by adding it as dependencies [14].

3. Test automation: This project type is used to create new test project.

4. Transactional process: Transactional process template is based on flowchart diagram. This can be used for complex automation process with large number of activities in it [15].

5. Robotic enterprise framework: Robotic enterprise framework template is based on state machines. It can be used for complex business process with large scale deployments. The default activities in this project template are excel, mail, credentials, system and UI automation [16].

6. Mobile testing project: This template can used for creating mobile app automates test cases.

7. Orchestration process: This template is used to implement the automation process through orchestration service and human intervention and long running workflows [17].

8. Background process: This template is used to create a process that runs in the background in parallel with another   process on the same robot on a condition that the background process doesn't use user interaction activities [18].

9. Trigger based attended automation: This is a sequence-based template used to trigger an automation process in response to mouse or keyboard events [19].

5.2 UiPath components

The main components in UiPath studio are ribbon tab, activity pane, property pane and output pane. The ribbon tab has recording, screen scraping options for imitating human activities for desktop automation, manage packages for installing the activity dependencies for the workflow, publish option for publishing the workflow process. The *Activities* pane consists of set of activities to create the workflow process. The *Properties* window is used to configure the property of each activity to provide connection between activities in the workflow. The *Output* pane shows the details of process execution with project dependencies.

5.3 UiPath activities

UiPath studio consists of several activities which are integrated into packages. There exist few default packages presented as dependencies when a new project is created in the studio. These packages include excel, mail, system and UI automation activities. In addition to these, database and PDF activities are installed to develop the RPA application. Some of the relevant activities used for thesis are described below.

1. Excel activities package: It consists of several activities to perform excel automation. These are available under system and app integration in the studio. Common examples include excel application scope, read range, write range etc [20].

2. PDF activities package: PDF activity package consists of activities that can read pdf document, extract specific data or entire document, merge files, etc. These are available under app integration in the studio. Some of the activities are read pdf text, join pdf files, get pdf page count [21].

3. Database activities package: This package contains activities to connect to server database. It includes, connect, disconnect, execute and non-execute query. These activities are grouped under app integration [22]

4. System activities package: It consists of basic activities that are used for creating workflow process. Some of the activities used are data table operations such as add data row, for each row and invoke code, if else activity. These activities available under programming, UI automation and system in studio.

5. UI Automation activity package: These activities are used to perform mouse or keyboard actions like clicking or typing the information, opening application as human does. Some of the activities used are type into, start process, anchor base, found element, get text etc [23].

5.4 UiPath robot

Robot executes the processes that are developed using activities in UiPath studio. It can be unattended or attended robot. An unattended robot can run the process without human intervention whereas the attended robot works as an assistant and the process triggered by human. The robot needs to be installed with the studio to execute the workflows and to establish a connection with the orchestrator [24]. Figure 5.3 shows that the automation projects in UiPath studio are executed by the robot.
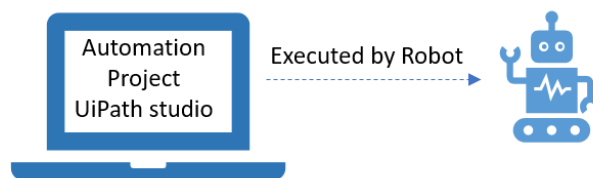

Figure 5.3: Execution of automation project in UiPath studio

5.5 UiPath orchestrator

UiPath orchestrator is a web application that is used to deploy processes, and then monitor, schedule and manage robots to execute the processes on various machines. The user interface of the orchestrator consists robots, machines, processes, triggers, jobs, logs [25]. The robot installed on the computer is needed to connect with the orchestrator. Figure 5.4 shows execution of automation processes on various machines by the robot assigned in orchestrator.

The important components of the orchestrator are described next.

1. Machines: The machine or computer name must be added in the orchestrator for executing the automation processes on that machine by assigning a robot. Machine name can be added in the *MACHINES* under the *Management Menu* in the orchestrator.

2. Robots: Robot is used to execute the automation processes on various machines. Robots can be added in the *ROBOTS* tab under the *Management Menu* in the orchestrator.

3. Processes: Automation processes can be deployed to the orchestrator after publishing them from the UiPath studio. *PROCESSES* under the *Automations Menu* is used for deploying the published projects.

4. Jobs: *JOBS* under the *Monitoring Menu* in the orchestrator is used to start the execution by selecting the process and assigning a robot to it.

5. Triggers: *TRIGGERS* under the *Automations Menu* is used to schedule jobs for the robots.

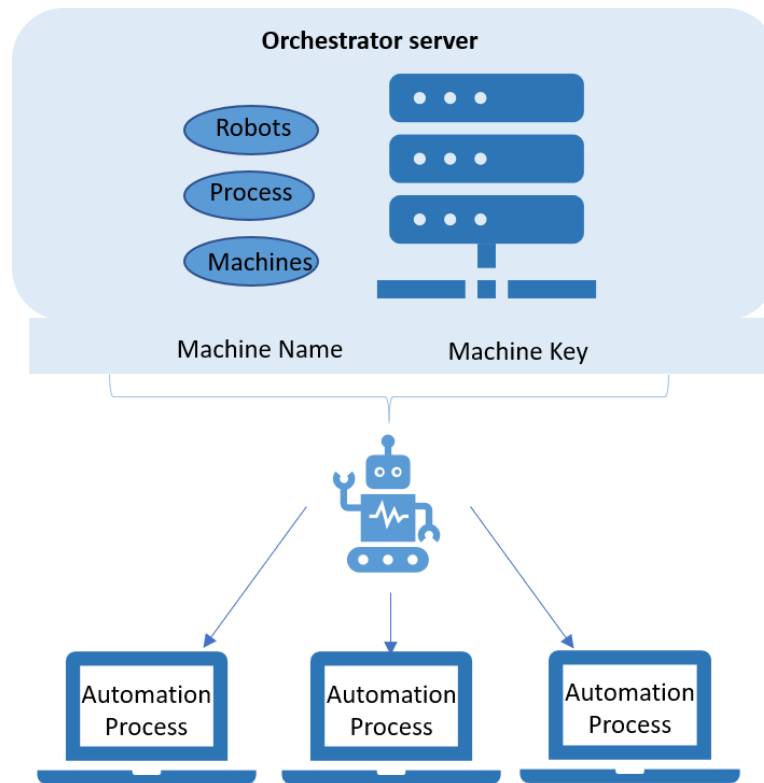6. Logs: *LOGS* under the *Monitoring Menu* shows the details of executions performed by the robot.

Figure 5.4: Execution of automation projects on various machines by assigned robot in orchestrator

The enterprise version of the UiPath comes with the orchestrator server. The installation of orchestrator on a computer needs some hardware [26] and software [27] requirements along with prerequisites for the installation [28].

6 Interview of Healthcare Employees

As discussed in Chapter 3, the first phase of RPA is identifying the tasks and analyzing them to check whether the tasks can be automated or not. This chapter presents the interview of healthcare employees and analysis of the data for identifying potential use cases for implementing RPA. The questionnaire for the interview can be found in appendix B.

6.1 Interview of healthcare employees at STHF

The main criteria for automating any task is that it should be repetitive, time consuming and rule based. To find such type of tasks in healthcare industry, an interview is conducted with healthcare employees at STHF. A questionnaire is prepared with a set of questions related to their tasks at the hospital, management of patient health records and access of patient data. The interview data is analysed by organizing it in the form of three tables 1) patient data management and synchronization, 2) data storage and security, 3) administrative tasks. Next section describes each of these tables in detail.

6.1.1 Patient data management and access

DIPS EHR is used at STHF for patient record system. An EHR consists of patient's administrative details such name, age, address, etc, and health data such as laboratory results, X-ray scans, pathology test reports. MetaVision clinical information system contains the medication information of the patient. It is also used to view the patients health information in real time using a chart system. Medication and dosage for the patients is recorded using MetaVision system. These data can be accessed by the employees via DIPS or MetaVision systems based on their role and department at the hospital. The interview related to patient data management and access is provided in Table 6.1.

Table 6.1: Data management and data access

Employee	Data management	Data access
1. Employee #1	o An electronic health record (EHR) consists of patient's administrative and health data. The DIPS application is used as EHR at sthf. o Also, a chart system consists patient's medication and vital data related to patient's health.	o DIPS application has all the data related to patient. The hospital employees have access to this application depending their role and department.
2. Employee #2	o Data is managed by Sykehuspartner. It is the ICT supplier and support organization for the hospital.	o Employee sends request to ICT supplier to get access to the required data

3. Employee #3	○ EHR consists of patient appointments, lab results, x-ray results, pathology report, documents from other hospitals, economy data like billings etc. Sykehuspartner manages all this data	○ Employee have access to the data depending on their role
4. Employee #4	○ Medical data is not in one file with some structure. It appears in different windows in DIPS application or MetaVision	○ Data synchronization is done using HL7 protocol

6.1.2 Data storage and data security

All the patient data is stored in a database, which is managed by Sykehuspartner, an ICT supplier for the hospital. Hospital employees send a request to the ICT supplier to get access for the required data. The information for public display such as number patients beds available, number of operations performed in a day will be displayed using the dashboard of QV. For this, the data is obtained from DIPS followed by information processing and the results are is saved in csv files for use by the QV dashboard, which is updated every day. The data fetching and processing is restricted to bonafide employees through authorization. The interview data related to patient data storage and security is given in Table 6.2.

Table 6.2: Data storage and data security

Employee	Data storage	Data security
1. Employee #1	○ Patient data is stored DIPS application and medication data in chart system using MetaVision database.	○ Identity manager regulates the central system gives access to employee by authorization and authentication using IDM. IDM has an active directory that consists of role of every employee. Every access will be logged and saved in the system.
2. Employee #2	○ Data is stored in QuickView, excel, csv.	○ Employee roles that give access to the patient data/ database.

3. Employee #3	o Sykehus partner manages all the data	o Employee have access to the data depending on their role
4. Employee #4	o Sykehus partner manages all the data o Important data will be stored local device for backup if there is any loss in power or internet	o Employee has access to the database based on their role
5. Employee #5	o -	o Coders will have access to all the data depending on the necessity

6.2 Potential use cases for RPA applications at STHF

From the interview data, the repetitive and tedious tasks are identified and structured into the Table 6.3. It has been observed that the doctors and the medical coders are spending a lot of time on reading documents to find diagnosis related words and entering patient data into various applications. Implementing RPA technology for these kinds of tasks will definitely save the time of doctors and coders by releasing them from these tiresome jobs. The use cases that are suitable for RPA application are summarized in Table 6.3.

Table 6.3: Use cases for RPA applications

Employee	Repetitive and tedious tasks	Use cases for RPA application
1. Employee #2	o Delivering patient information and displaying overview of the hospital in dashboard using QV software	o -
2. Employee #3	o Doctor has to enter cancer patient data in cancer registry NHR other than in DIPS o Doctor should read the patient document to decide the patient's visit to the hospital o Quality check (sending codes to NPR to claim money)	o Entering cancer patient data in cancer registry which is National Health Record o Doctors spent time reading the document consists of patient's health issues to decide when the patient can visit the hospital and sends a message to the secretary for the appointment scheduling

3. Employee #4	o Documentation task for preparing the dose (medicine) for patients in MetaVision and keeping the medicine in the medical dispenser box o Doctor has to add the medication data to the epicrisis document (Epicrisis is the document written by the doctor after the operation or the treatment)	o Doctor adds the medication data to the epicrisis document o Documentation task for preparing the dose (medicine) for patients in MetaVision
4. Employee #5	o The codes that are sent back from NPR need to be checked o Reading the documents and getting clarification from the doctors for wrong codes or codes that differ with the code registry	o Sending codes to NPR with single diagnosis which is having single code. Usually, patients who visits the doctor and leaves the hospital within a day will be having single diagnosis

The use cases are categorized into three types of automation based on the type of task. Three use cases from each of these automation categories are chosen for RPA implementation. RPA developer needs access to the DIPS and MetaVision for implementing the RPA applications at the hospital. Based on the interview, the use cases identified for RPA implementation are described in Table 6.4.

Table 6.4: Potential use cases for RPA

Use cases	Type of task	Type of Automation	Database access
1. Reading the patient's health issues document for appointment scheduling	Document Reading & finding key words	PDF automation & Keyword search automation	Need access to DIPS
2. Adding patient medication data to the epicrisis document	Data entry	Data entry automation	Need access to DIPS & MetaVision

3.	Searching for diagnosis keywords in epicrisis document	Document Reading & finding key words	PDF automation & Keyword search automation	Need access to DIPS
4.	For quality check task, sending codes to NPR with single diagnosis to claim the money	Document Reading, finding key words and data entry	PDF automation & Keyword search automation	Need access to DIPS
5.	Preparing the medication dose for patients in MetaVision	Documentation	Data entry automation	Need access to MetaVision
6.	Entering cancer patient data in NHR	Data entry	Data entry automation	Need access to DIPS and NHR

7 RPA Implementation

As discussed in Chapter 6, the use cases are related to data entry automation, PDF automation and key word search automation. One use case from each automation type is chosen for implementing the RPA application. Implementation of actual use cases 1 to 6 as mentioned in chapter 6 Table 6.4 requires access to restricted software and registries DIPS, NHR, NPR, and MetaVision. To overcome this problem, a test registration software with minimal features is developed as simple representative for DIPS using C#. However, such a workaround for NHR, NPR, and Metavision is not possible. Hence, in this thesis only equivalent of use cases 1 to 3 are considered for implementation. The selected use cases are 1) reading patient medical form, 2) entering patient details into patient registration software, and 3) finding diagnosis related keywords in epicrisis document. This chapter describes the RPA implementation of each use case in detail.

7.1 Use case 1: PDF automation- Reading patient medical form

Patients fill enrolment form which contains personal details, medical history, and other relevant information. A sample patient medical form is given in appendix C. It is assumed that that these medical forms are then scanned with a OCR device and saved as a PDF document by the hospital personnel. In this automation process the robot extracts the patient details and medical history from the PDF document of the medical form and saves the information in an excel sheet. There are two phases namely design phase and development phased associated with developing the RPA for this process, which are explained next.

7.1.1 Design phase

In the design, a flow chart as shown in Figure 7.1 is prepared with the sequence of steps leading to the automation process for reading the patient medical forms.
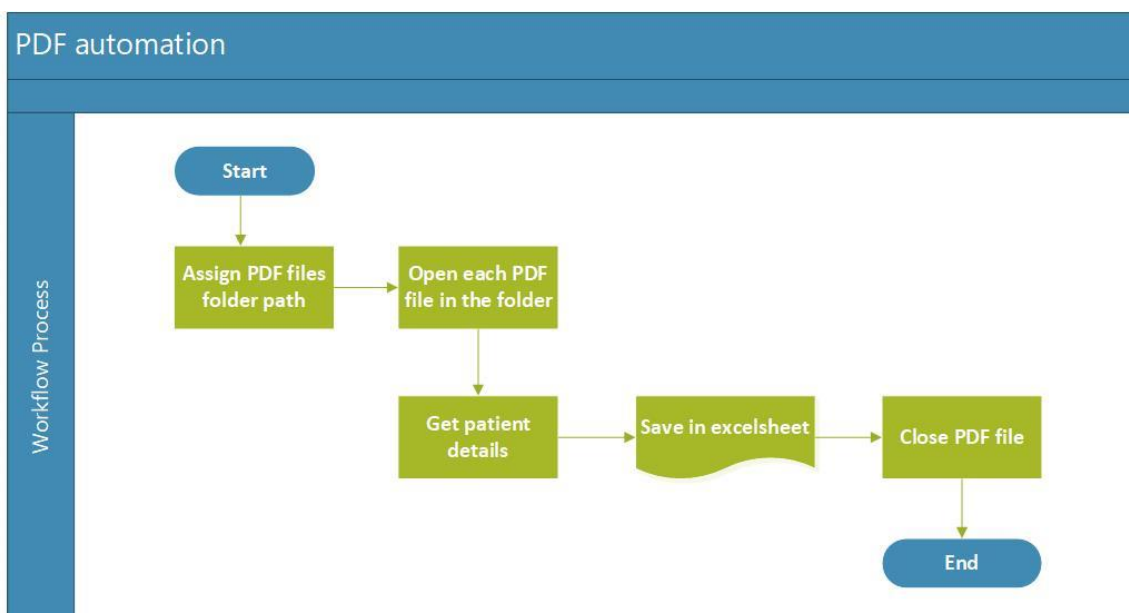

Figure 7.1: Flow chart of reading patient medical forms

7.1.2 Development phase

Next in the development phase, the workflow process for reading medical forms is developed in UiPath studio using basic activities. 'For Each' activity is used to open each pdf file stored in a specific path of the local drive. The activities such as 'Anchor Base', 'Find Element' and 'Get Text' are used to read personal details filled by the patient. Patient medical history is extracted using 'Find Image Matches' activity by reading the checkbox name if it is marked by the patient. The snapshot of the workflow process for reading the medical forms is shown in Figure 7.2. The output excel sheet shows the patient details extracted from patient medical form will be as shown in Figure 7.3.
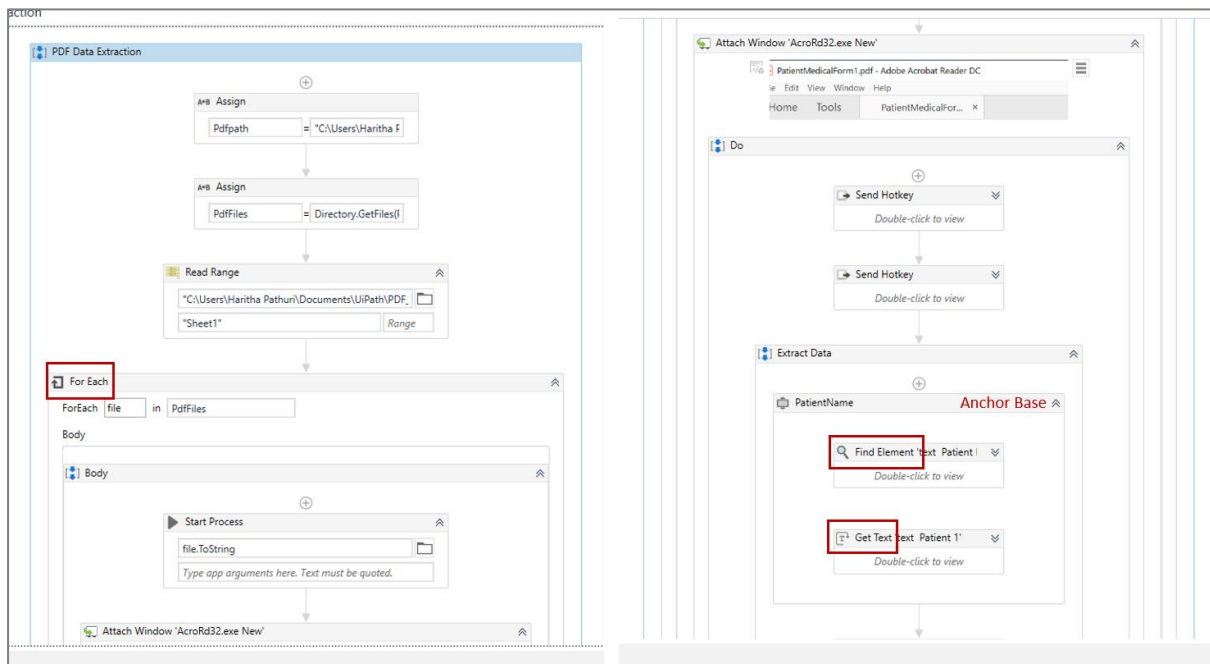
Figure 7.2: Snapshot of workflow process for reading medical forms created in UiPath studio

Figure 7 3: Snapshot of excel sheet of patient details extracted from medical document

7.2 Use case 2: Data entry automation – Entering data to patient registration software

In this automation process, the robot reads the patient details and medical history from excel sheet that is generated in the previous use case. Then the robot enters these details into patient registration software. First, it searches for the patient record if it already exists in the database. If there is a match then the robot skips to the next patient, otherwise it enters and submit the details of the patient record.

Since the access to live patient registration software in the hospital is restricted, this thesis created a test registration software with minimal features using C#. This is essential to test the and build the RPA application. Figure 7.4 shows the GUI of developed patient registration software that takes input as patient name, gender, age, height, weight, phone number, email, reason for seeing the doctor and medical history of patient. The software application stores the patient details in a SQL server database. In GUI of registration software, the details submitted are shown in a table named Data Registered and the table named `Patient Records` shows the patient details if the robot finds that patient has been already existing in the database.

The patient details are stored in a database table named *PatientDataEntry* which is created in the SQL database named *RPA_Uipath*. Figure 7.5 shows the patient details stored in *PatientDataEntry* table in SQL database.

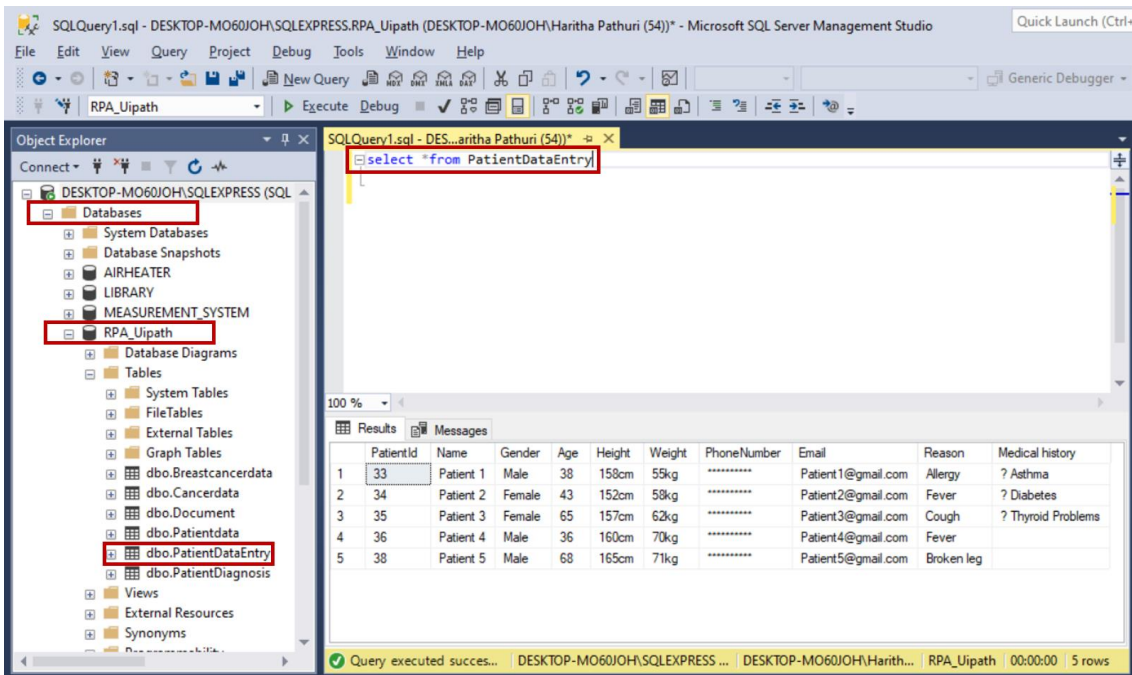Figure 7.4: GUI of patient registration software

Figure 7.5: Patient details stored in *PatientDataEntry* table in SQL server

There are two phases namely design phase and development phased associated with developing the RPA for this process, which are explained next.

7.2.1 Design phase

A flow chart is created with sequence of steps to develop the data entry automation. Figure 7.6 shows the flow chart of entering data to patient registration application.
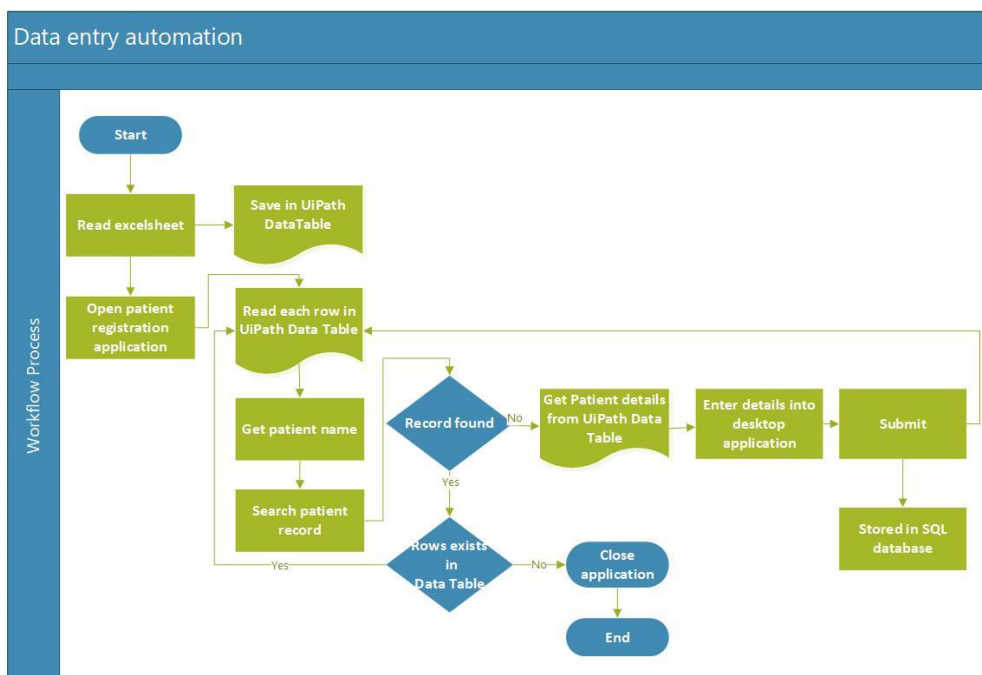

Figure 7.6: Flow chart of data entry automation

7.2.2 Development phase

The workflow process of data entry automation developed in UiPath studio. It consists of three sequences in a flowchart. Each sequence has set of activities to perform to automate the process. Figure 7.7 shows the workflow process for data entry automation created in UiPath studio. The three steps are

1. Read excel sheet:

   This step will extract the data from excel sheet and store it in a data table in UiPath studio using 'Excel application scope' and 'Read Range' activities.

2. Open application

   'Open Application' activity is used to open the patient registration software. The path of the application should be given in the filename tab of the 'Open Application' activity properties and the selector must be validated.

3. Data entry application

   Data entry application sequence consists of 'For Each Row' activity to go through each row of the data table in UiPath. It takes the first element of the row in data table which is the patient name and enters patient name in the opened patient registration software and searches for the patient record. 'Type Into' and 'Click' activities are used for entering details and searching the patient record. 'Get Text' and 'If' activities are used to check if the patient record exists or not. 'Click' activity is used to close registration software.
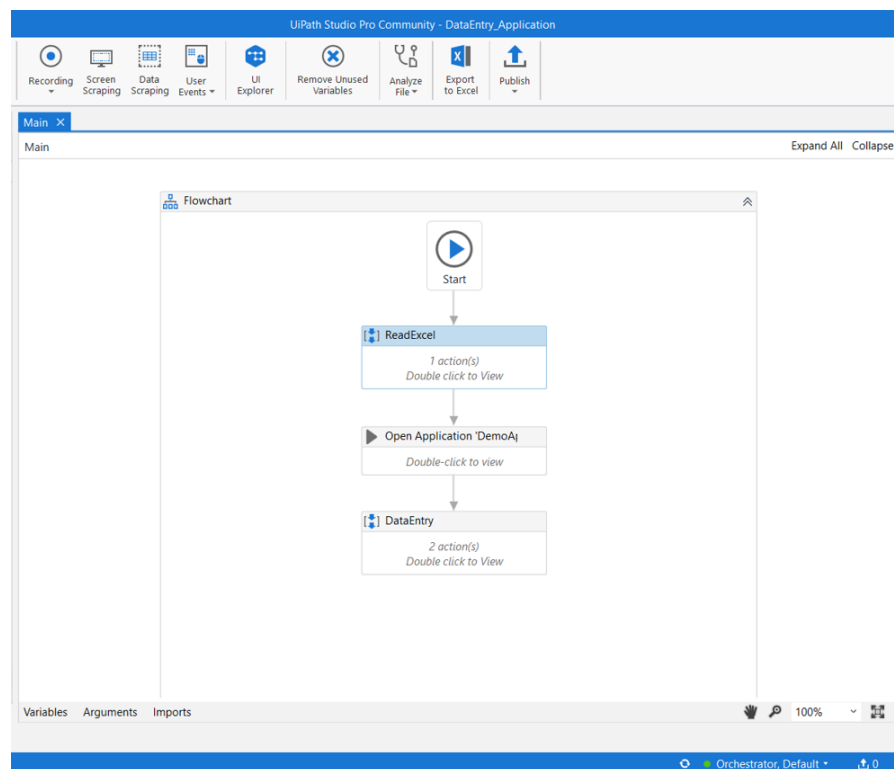

Figure 7.7: The workflow process for data entry automation in UiPath studio

7.3 Use case 3: Keyword search automation - Finding diagnosis keywords in document

Use Case 3 considers finding diagnosis keywords in epicrisis document as a client-side RPA application where the robot first communicates with the SQL server database to obtain the epicrisis document stored in a table and then find the diagnosis keywords in it, which are later saved in another table in the remote database.

After fetching the epicrisis document from the *Document* table, the robot performs a data type conversion of the document from binary large object (BLOB) to text, and then searches for keywords related to diagnosis in the text by comparing with a list of keywords in an excel sheet present in the local drive. Next, it stores the found diagnosis keywords along with the patient id in the *Patient Diagnosis* table.

Figure 7.8 shows the sample epicrisis documents stored in the SQL server database *Document* table. These two tables *Document* and *Patient Diagnosis* are created in *RPA_UiPath* database in the SQL server.
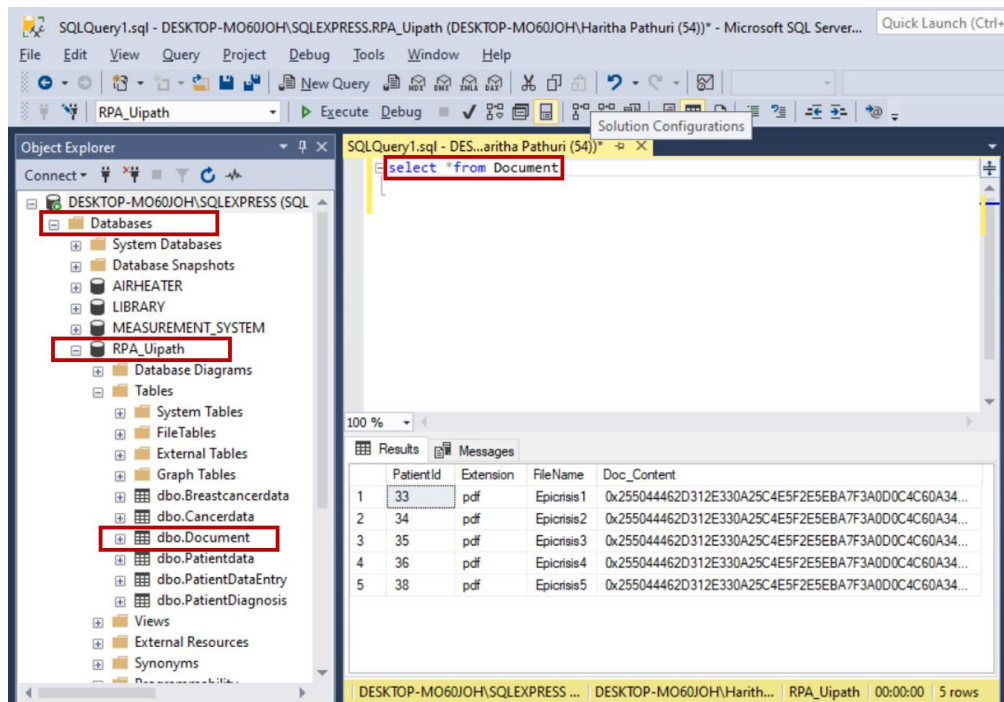

Figure 7.8: Epicrisis documents stored in the SQL server database *Document* table

7.3.1 Design phase

In the design phase, a flowchart is created with sequence of steps to find the diagnosis keywords in the epicrisis document. Figure 7.9 shows the flowchart of keyword search automation.
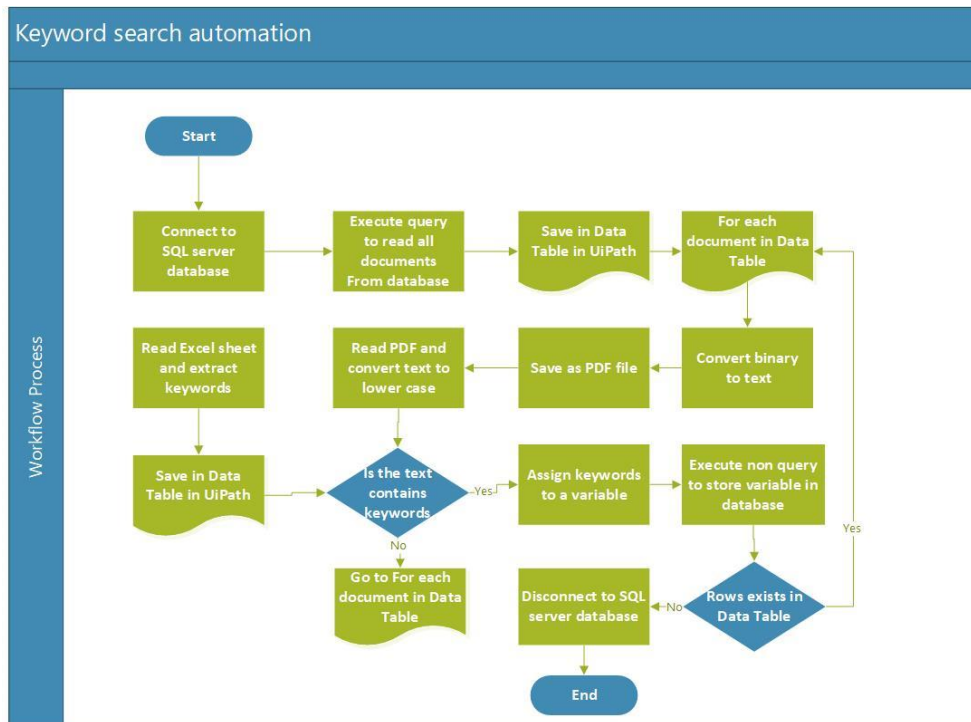
Figure 7.9: Flow chart of keyword search automation

7.3.2 Development phase

For the development process we need database activity and PDF activity packages to be installed in addition to the basic activity packages. Figure 7.10 shows the snapshot of the workflow process for keyword search automation in the UiPath studio. The development of this automation process is explained below in detail.

1. Connect to database:
   To read the epicrisis document from the SQL server database, a connection needs to be established between the UiPath studio and the SQL server. 'Connect' activity from database package is used and configured to establish the connection and the output of this activity is a connection string which will be used further to execute queries and disconnect from the database. 'Execute Query' activity is used to read the epicrisis documents from the database and then saved to a data table.
2. Convert binary large object (BLOB) data to text:
   The epicrisis documents are saved in data table as binary data type. For converting binary to text, 'For Each Row' and 'Invoke Code' activities are used. VB.Net code is inserted in the 'Invoke Code' activity for converting binary data to text and then text as pdf file is saved in the project location.
3. Searching keywords:
   An excel sheet with the diagnosis related words is placed in project location. The PDF file of each epicrisis document is verified using 'Contains' method for finding the keywords that are presented in the excel sheet. If the keywords are present, then they are assigned to a string variable.
4. Storing keywords in database:

The keywords in the string variable are stored in SQL server database using 'Non-Execute Query' activity. The connection string is used to connect to existing database. Figure 7.11 shows the diagnosis keywords stored in SQL server database table.

5. Disconnect database:

After finding keywords in all the epicrisis documents, the connection to the SQL server is disconnected using 'Disconnect' database activity
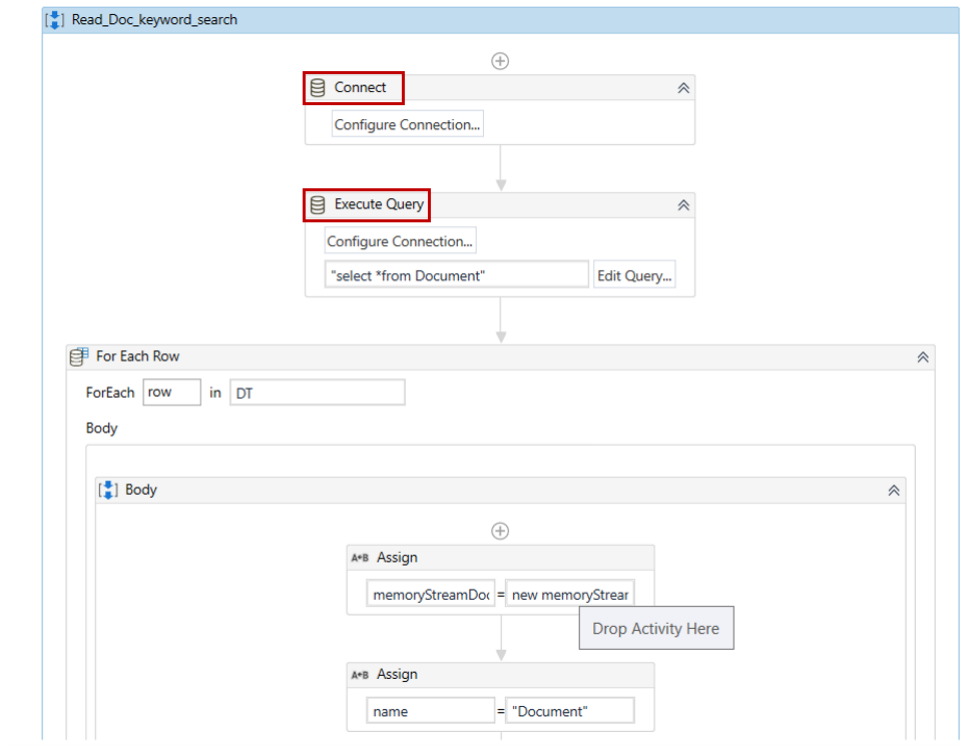

Figure 7.10: Snapshot of workflow process for keyword search automation in UiPath studio

Figure 7.11: Diagnosis keywords are stored in SQL server database table

8 Deployment of Applications

The deployment of the automation processes can be done using the publish button in the UiPath studio. After the deployment, the processes can be executed by the robots. This chapter describes deployment and execution of the automation processes using UiPath robot from system tray and by assigning robots from orchestrator.

8.1 Using UiPath robot

When the UiPath studio is not connected to the orchestrator, the automation process can be deployed and executed using the locally installed UiPath robot in the computer. In this method, the automation processes are published to the local drive and deployed to the robot from the system tray.

The deployed automation processes can be seen in the UiPath assistant under the process list. These processes can be executed by the robot with one manual click. The UiPath assistant with the deployed processes is shown in Figure 8.1.
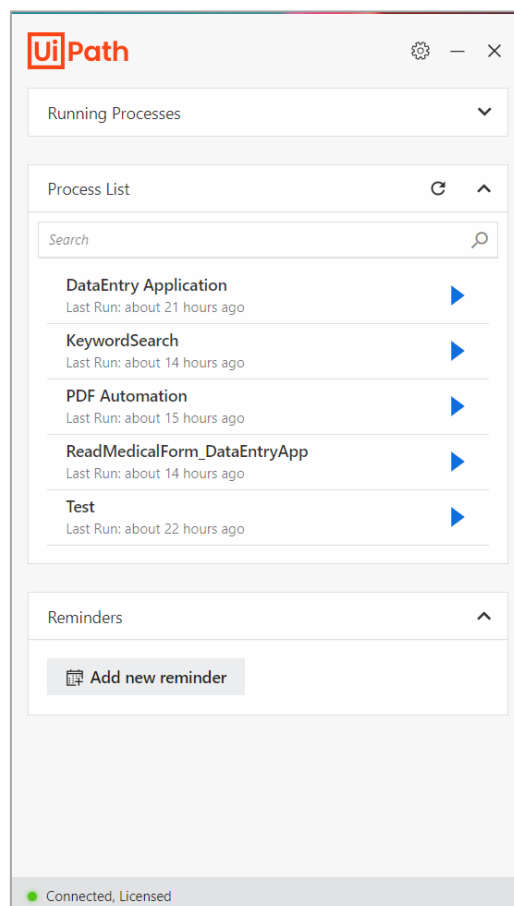

Figure 8.1: UiPath robot from system tray with the deployed automation processes

8.2 Deployment and execution using orchestrator

The automation processes that are deployed to the orchestrator can be executed on various computers in the network. For this, the automation processes must be published to the orchestrator. This can be done by connecting UiPath robot from system tray to the orchestrator.

8.2.1 Connecting UiPath robot to orchestrator

The UiPath robot can connected to the orchestrator through the following steps

1. Login to orchestrator web application
2. Add the local machine to the orchestrator using *MACHINES* tab under Management menu
3. Add the robot in the *ROBOTS* tab. Here, the existing machine name, robot name, user-name and password of the computer and the type of robot must be entered.
4. Copy the machine key that is available in the *MACHINES* tab. Machine key is available only after the machine name is added.
5. Open the orchestrator settings in UiPath robot from system tray
6. Enter orchestrator URL and the machine key
7. The UiPath robot can be connected to the orchestrator by clicking the connect button. (Figure 8.3 shows an example of orchestrator settings in the UiPath robot from system tray)
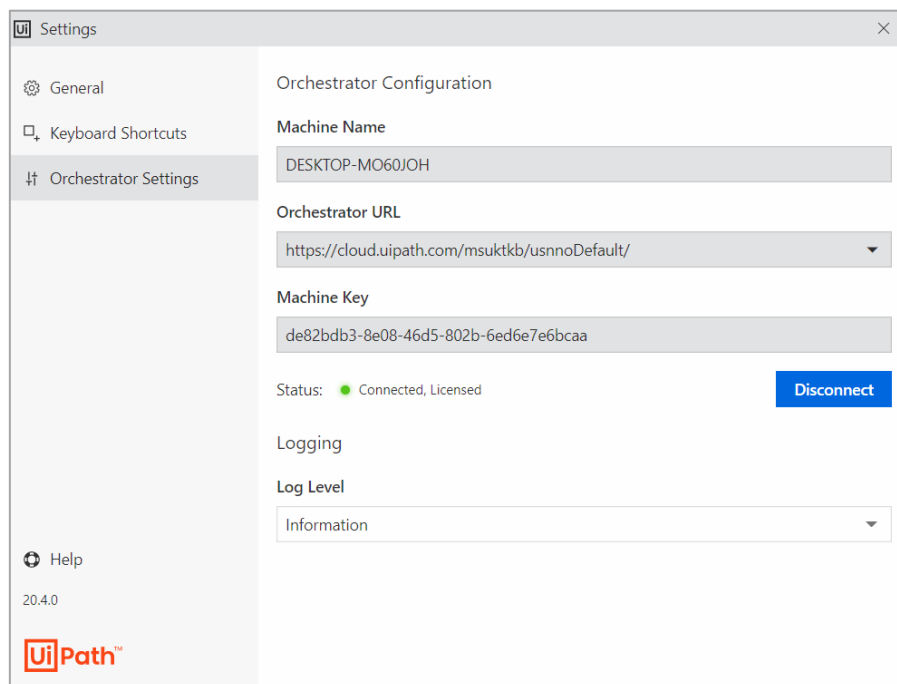

Figure 8.3: Orchestrator settings in the UiPath robot from system tray

8.2.2 Deployment of processes to the orchestrator

Connecting UiPath robot tray to the orchestrator will also connect the UiPath studio to orchestrator. Now the automation processes can be published directly to the orchestrator from

the UiPath studio. Automation processes can be deployed in the orchestrator using *PROCESSES* tab by using the add button and then entering the published process name in the Package Name field in the orchestrator UI. In order to execute the deployed process in the orchestrator, an environment has to be created in the orchestrator UI for grouping the robots and already deployed processes. Figure 8.4 shows the automation process deployed in the orchestrator. Figure 8.5 shows the Orchestrator UI displaying the available robot with machine name and the environments.
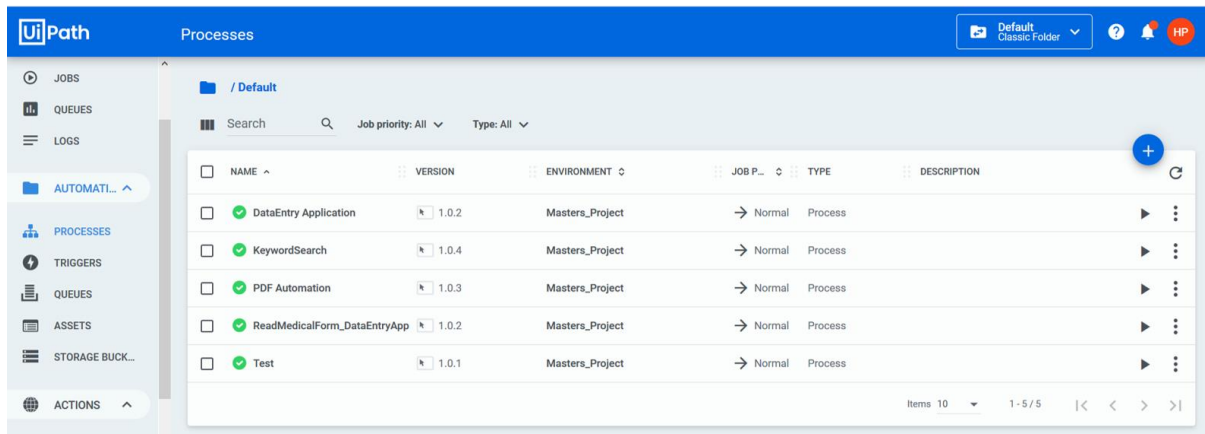
Figure 8.4: Automation process deployed in the orchestrator
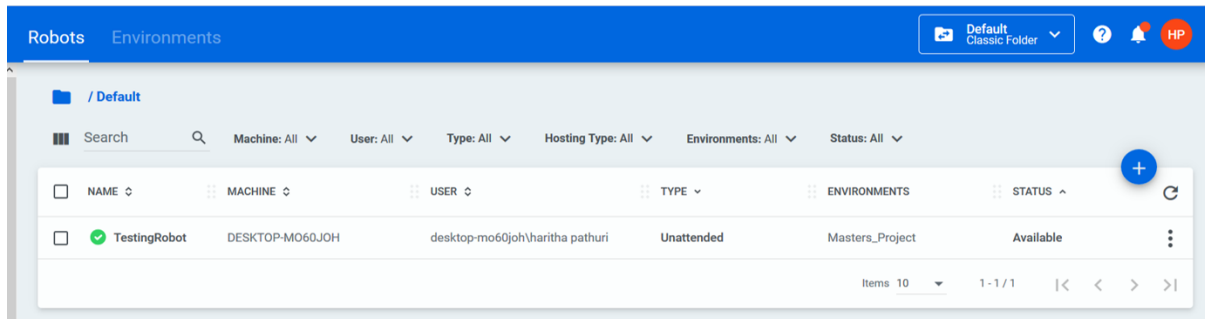
Figure 8.5: Orchestrator user interface showing the available robot with machine name and the environments

8.2.3 Execution of automation processes

The *JOBS* tab in the orchestrator is used to start the execution by selecting the automation process and assigning the robot to the machine. Figure 8.6 shows start job of use case 3 - keyword search automation process with the assigned robot. The execution of the process will be performed on the machine to which the robot has assigned. Robots can be scheduled to perform the execution on specified day or time using the *TRIGGERS* in the orchestrator. Also, the orchestrator saves the details of every execution performed by the robots. These details will be shown in the *LOGS* tab of the *Monitoring* menu. Figure 8.7 shows the executed automation processes in the orchestrator.
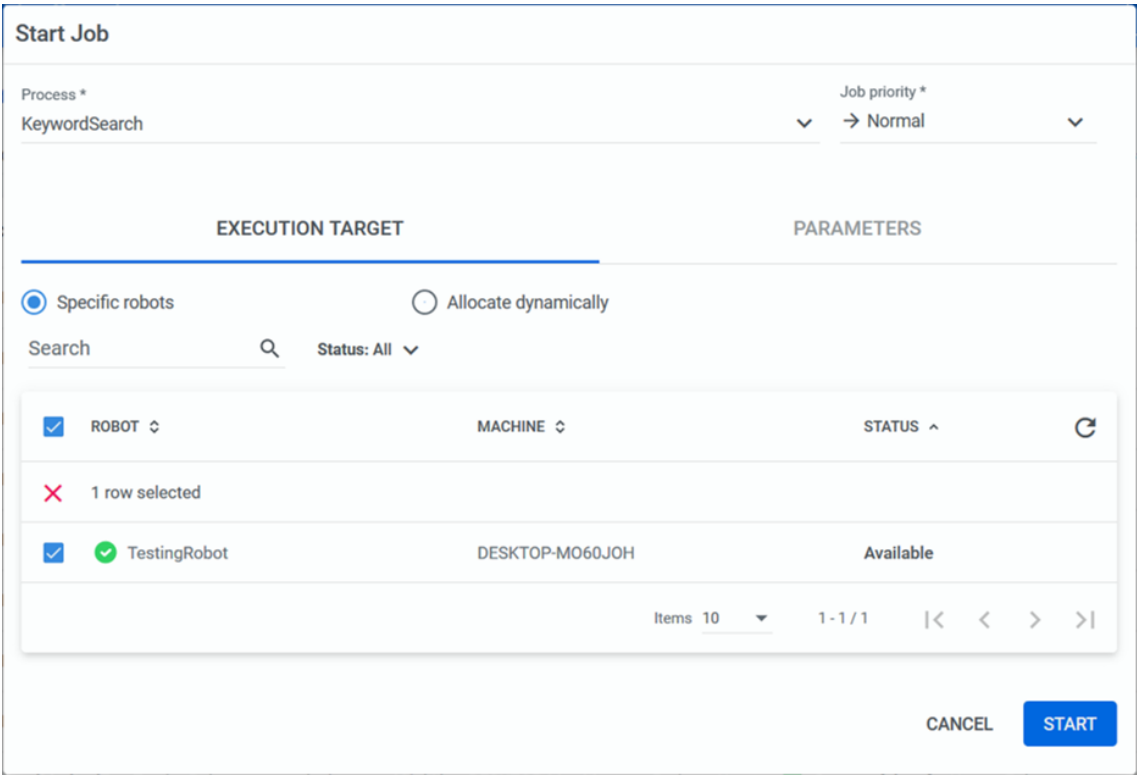
Figure 8.6: Assigning job to the robot in the orchestrator

Figure 8.7: Executed automation processes in the orchestrator

Important numbers such as number of process deployed, number of robots available are shown in the dashboard of the orchestrator as shown in Figure 8.8.

Figure 8.8: Dashboard of the web orchestrator showing number of process deployed and number of robots available

9 Additional Aspects in Automation

9.1 GDPR

General Data Protection Regulation (GDPR) is a EU regulation enforce from 2018 to protect personal data. This regulation is applied for collection and processing of personal data in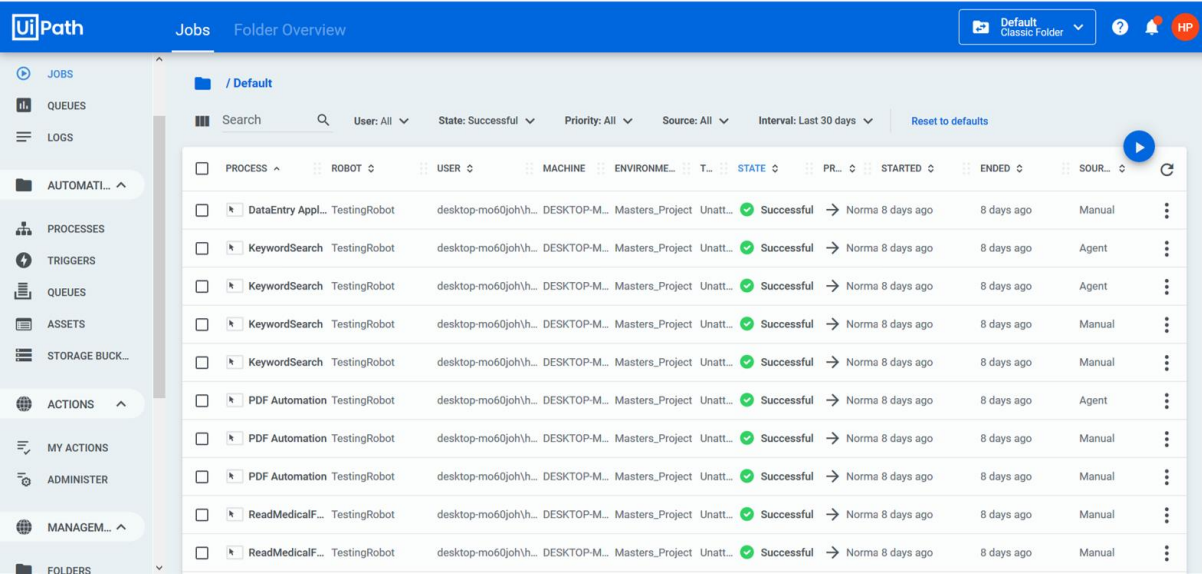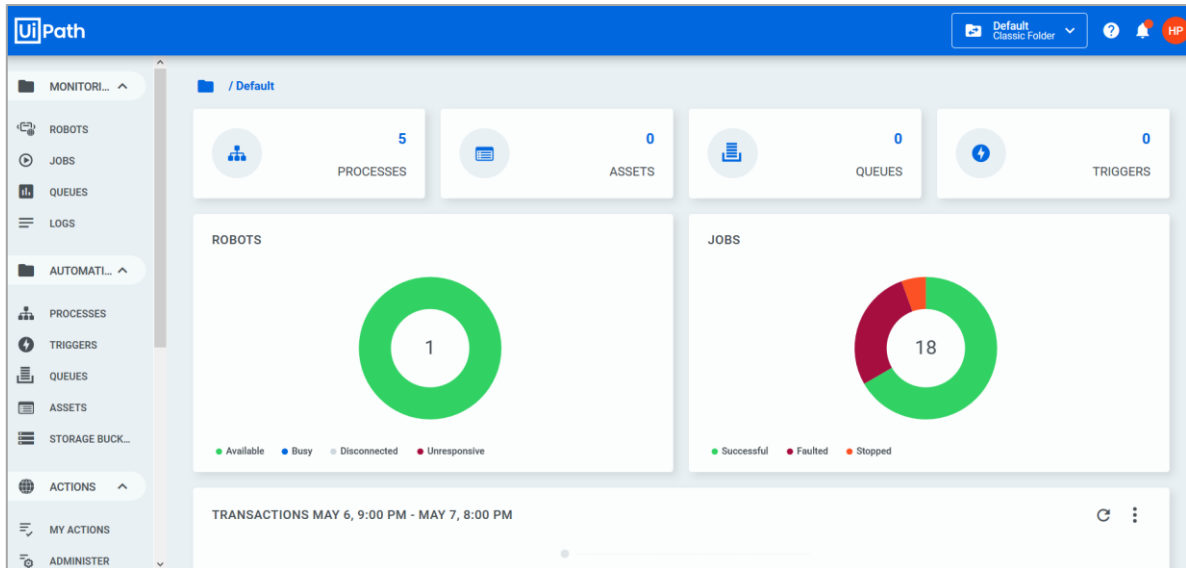 the EU member nation. The data collected includes personal data, which is any data that about an individual such as name, age, date of birth, addresses, email, cookies, website preferences, etc. The regulation also protects other personal information such as genetic, biometric, and health data such as health, physical condition, gender, ethnicity, facial images, fingerprints, iris scans, and data collected by health agencies such as physical and mental health, treatment, and medical history. GDPR give comprehensive regulations on collection, storage, usage, and retention of data. Regulator are assigned responsibility to check compliance and levy penalt if any the entities are found violating the GDPR. Under these regulations, users have the right to access data that has been collected, and also the right to request for changing wrong personal data, right to data deletion and right to restrict processing. It also instructs protocols for the entities to notify any case of security attacks and privacy loss.

9.2 Data security

Automation increases security threat both external and internal increase. These threats arise due to external adversaries, internal adversaries, poor design, network deficiencies, many applications use private and confidential data such as patient records or bank account and personal information. However, features of RPA help in enhancing security due to limited access to humans to sensitive data, extensive logging can help audit and automated security detection.

The main sources of risks are 1) robots have credentials to access to databases and breach of robots may lead to exposure or stealing of credentials 2) robots may unintentionally expose data during the process of reporting or execution 3) unauthorized entities can access the robots to create mischief.

However, with security mechanisms some of these can be easily avoided. 1) robust password management, the passwords and credentials used by the robust is encrypted rather than storing as plain text. Only the robot can decrypt during its execution. 2) role-based access mechanism where single sign on authentication, multi-factor authentication scheme provides selected access to services and systems based on assigned roles. 3) the robots can be programmed to compliance to GDPR and communication protocols to securely transmitted data using SSL and TLS with other authorized entities. 4) perform vulnerability analysis by using rigorous audit and log trails can implemented with robot operation for forensic analysis to prevent malicious behavior.

9.3 RPA with machine learning

RPA is intended to automate repetitive tasks performed by human. It can only imitate human actions but cannot use any intelligence in performing the tasks or with the outcome of the tasks. Other ML provides algorithms to act upon the data and draw inference from the available data. Hence RPA and ML complement each other. Thus, combing RPA and ML will lead to intelligent automation where not only the tasks are performed without human intervention the application can also provide its observation, detect patterns, and transform data into actionable intelligence. RPA can perform the task of data preprocessing such as converting the data format, removing missing entries, etc, to improve the efficiency and accuracy of the ML algorithms. Since the capabilities of ML algorithms depend the training data available, RPA gather large amounts of data from wide range of sources. Hence combination of RPA and ML algorithms will allow adaptability and robustness to automation process. For example, consider the shortlisting process for interviews for hiring. The RPA bots can download the CV of the applicants and extract information such as experience, skillset. This data can be processed by ML algorithms to determine the suitability of an applicant for the position advertised. Another example is processing the invoices. The RPA bots can sort the emails received, obtain receipts and payments, and then tabulate the processed invoices along with data extracted from the process. The ML algorithms can be trained on this data set to obtain the statistics or assign credit ratings.

10 Conclusion

The main objective of this thesis were to identify and automate the repetitive and time-consuming manual tasks of healthcare employees by using RPA technology. The identification of such monotonous tasks was done by conducting interviews with healthcare employees at STHF. Six potential use cases were found for the RPA application after analyzing the interview. The identified use cases are 1) reading the patient's health record for appointment scheduling, 2) adding patient medication data to the epicrisis document, 3) searching for diagnosis keywords in epicrisis document, 4) sending diagnosis codes to NPR, 5) preparing the medication dose for patients in MetaVision, 6) entering cancer patient data to NHR. Further, these tasks were divided into three categories of automation based on the workflow sequence of the tasks. One use case from each automation type was chosen for implementing the RPA application. Various RPA tools were evaluated for developing the automation process and community edition of UiPath was chosen as the most suitable RPA tool for our purpose.

Since implementation of actual use cases 1 to 6 requires access to restricted software at STHF, this thesis implemented the equivalent of use cases 1 to 3. The implemented use cases are 1) reading patient medical form, 2) entering patient details into patient registration software, and 3) finding diagnosis related keywords in epicrisis document. The developed RPA applications were deployed to the web orchestrator and a robot was assigned for executing the automated processes of use cases on the computer.

In the execution of use case1 reading patient medical form automated process, the robot extracted the patient details and medical history from the PDF document of the medical form and saved the information in an excel sheet. In the execution of use case 2 data entry automation process, the robot read the patient details and medical history from excel sheet that is generated in the previous use case and entered them into patient registration software. In the execution of use case 3 keyword search automation process, the robot first communicated with the SQL server database to obtain the epicrisis document stored in database table and then found the diagnosis keywords in it, which were later saved in another table in the remote database along with the patient id. Finally, the thesis studied other aspects of automation such as GDPR, data security, and machine learning for RPA.

10.1 Scope for future work

In this thesis work, the RPA application for the use case 1 was developed for the scanned PDF medical form by assuming that the original patient medical form filled by the patients was converted to text using OCR technology and then saved as text document. Initially, an attempt was made to read the scanned copy patient medical form with handwritten text in pdf form. The activities from Intelligent OCR package were used for implementing this automation process. But the robot could not precisely read the handwritten text due to limited functionalities and it was restricted to only printed text and not handwritten text. However, one can use image processing and machine learning techniques together with the RPA for better data extraction from hand-filled documents. Then the RPA application can be implemented for reading the details of the patient and transfer them to patient registration software. This RPA application with the ML algorithms is very generic that can be used for other tasks digitizing

handwritten medical forms and files thus enhancing the usage and saving even more time of the healthcare employees.

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Appendices

Appendix A <Project Description>

University of South-Eastern Norway

Faculty of Technology, Natural Sciences and Maritime Sciences, Campus Porsgrunn

FMH606 Master's Thesis

Title: Digitalization the Healthcare Industry by Implementing Robotic Process Automation and Machine Learning Solutions

USN supervisor: Hans-Petter Halvorsen, Nils-Olav Skeie and Olav Dæhli

External partner: STFH

Task background:

Robotic Process Automation **(**RPA) is a software robot that performs the tasks of one human through interaction with the user interface to one or more IT systems or computer programs. See and Figure 1 and Figure 2.

Today, health workers spend a lot of time solving rule-based and manual tasks, often across multiple systems. See Figure 3.
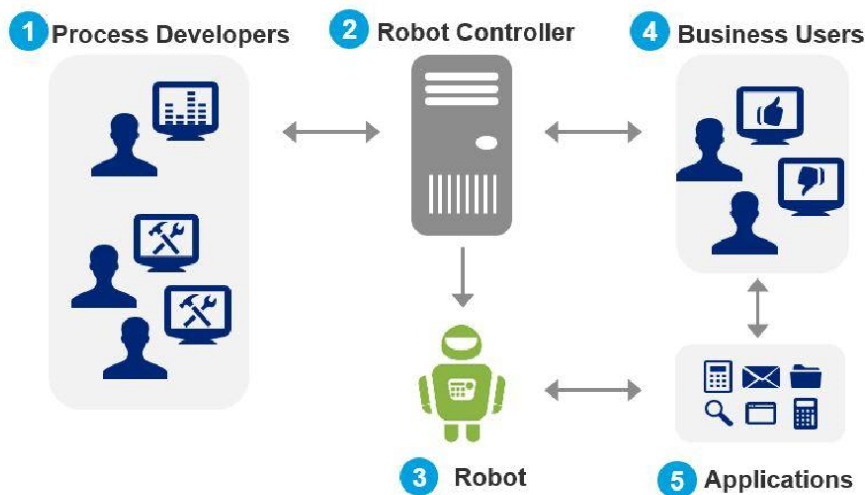

Figure 1: Steps involved in Robotic Process Automation (RPA)
[https://www.reddit.com/r/rpa_automation/comments/9fq4uk/how_does_rpa_work/]

To extend the practical utility of RPA we can combine it with Machine Learning (ML).

Task description:

In this project we will develop Robotic Process Automation (RPA) systems and increase the digitalization of the health industry in Norway in combination with Machine Learning (ML).
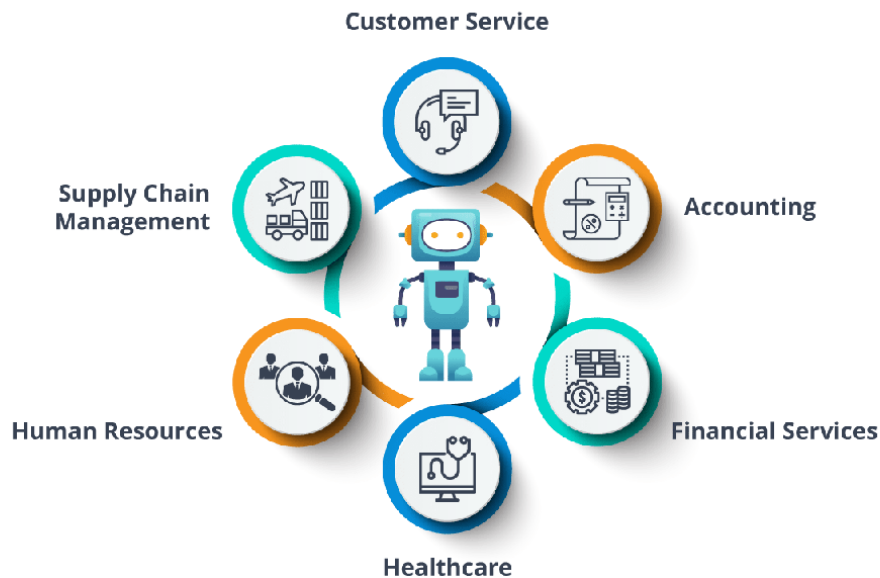

**Figure 2: Robotic Process Automation (RPA) in Healthcare and other Areas
[https://www.edureka.co/blog/what-is-robotic-process-automation/]**

Suggested Project Activities

The following activities are relevant in this project (which tasks that shall be part of this student project will be decided by the student in collaboration with the supervisors and external partners when the project starts):

- Make an overview of Robotic Process Automation RPA in general and evaluate it in a wider context like in the process industry and in health care.
- Make an overview of possible RPA applications and possibilities within Health Care Solutions. Robotic Process Automation (RPA) doesn't suit every process. You need to identify where we should use RPA at STFH. You should also see RPA applications in context of GDPR. The task should result in two answers:
  - Recommend a product based on various criteria such as price, functionality, availability, developer community and product support.
  - A priority list of tasks an RPA should either perform (replace manual job) or only support a manual job.
- Make an overview of tools that can be used for RPA applications. One such specialized tool is UiPath. Use of Python for RPA applications should also be considered. Software like UiPath is a commercial product, so open source alternatives should be considered.
- Evaluate how Machine Learning (ML) can extend the use of RPA applications
- Implement and test RPA on a practical case. You can use one of the cases found in the overview or use one of the following:

- o Support for the reception, assessment and further processing of electronic episodes
- o Increase the quality of medical coding of patient diagnoses and procedures through findings in individual patient's records and empirical data
- o For example, put bid diagnosis based on a main diagnosis
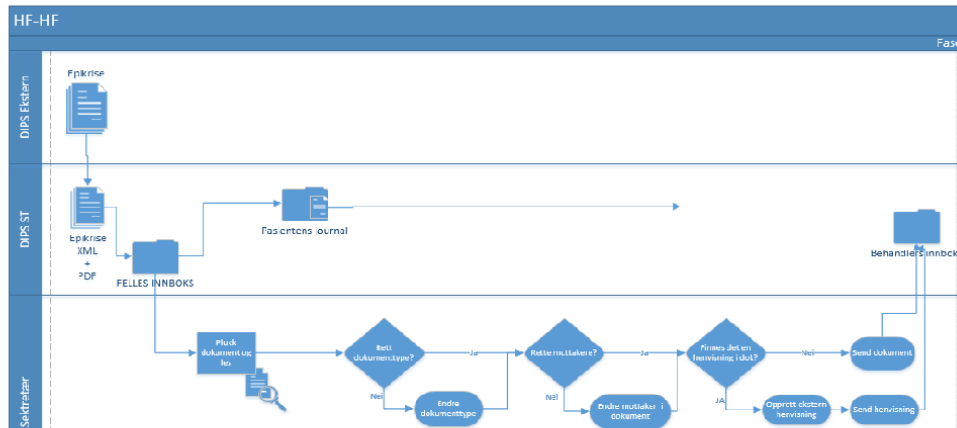- o For example, find incorrect codes and automatically correct or provide support for manual correction in journal

Figure 3: Typical Example of Document Flow at STFH

References:

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- Robotteknologi (RPA) - Evry - https://www.evry.com/no/bransjer-og-tjenester/key-services/kognitiv_teknologi_automatisering/robotteknologi_rpa/

Student category: IIA (suitable for Campus, Online or Industry Master students)

Practical arrangements:

All necessary software, equipment and access will be available. The project can be done from anywhere. Some meetings with external partner should be expected, but most meetings can be taken online using, e.g., Skype.

Supervision:

As a general rule, the student is entitled to 15-20 hours of supervision. This includes necessary time for the supervisor to prepare for supervision meetings (reading material to be discussed, etc).

Signatures:

Supervisor (date and signature): *Hans-Petter Halvorsen*

Student (write clearly in all capitalized letters): HARITHA PATHURI

Student (date and signature): *P. Haritha* 01.02.2020

Appendix B <Healthcare Industry Employees Interview>

Questionnaire for the healthcare industry employees:

Name	Haritha Pathuri
Job title	Master student in Industrial IT and Automation, University of South-Eastern Norway, Porsgrunn
Email	222141@student.usn.no

Introduction:

This questionnaire is to know about the tasks performed by the healthcare workers every day at hospital. Some of the tasks completed by healthcare employees are repetitive and sort of rule based and may also be tedious and time consuming. Such type of tasks can be automated using Robotic Process Automation (RPA) technology, where a software robot can perform these tasks with less time and makes employee available for some other important role. The information collected here will be used for my master thesis *'digitalization the healthcare industry using Robotic Process Automation and Machine learning solutions'*. The answers from the employees will be used as a source for choosing a task or area where the RPA can be implemented to digitalize the healthcare industry.

Please enter the following information	
Name	
Job title	
Email (optional)	
Please answer the questions that are relevant for you.	
I. General questions:	
1. What is your job description?	

2. What are the common tasks that are performed repeatedly while handling patients?

3. What are the generic tasks performed repeatedly that are not patient specific?

4. Which type of tasks are tedious and more time consuming?

5. What type of tasks the administrative staff does?

6. How much time is spent on billing and processing payments?

7. How often errors occur while doing these tasks?

8. In which type of tasks, you feel like having an assistance that will increase the work efficiency?

II.   Questions that are related to the data management:

1. What type of data does the Electronic Health Record (EHR) consist of?

2. How much time required to enter patient data and updating records?
3. What is the structure of medical record data?
4. How the data is transferred to the other departments/ data synchronization?

III.   Questions that are related to the data storage:
1. How the data is stored? (For example: Excel sheets, database servers)
2. Where the data is stored? Is it stored in a local device or cloud?

IV.   Questions that are related to the data security:
1. Who has access to different types of the data such as patient information, lab test results?

2. What are the mechanisms followed currently for data security of medical records according GDPR?

3. What data protection methods and unauthorized access prevention methods are used for security?

V. Questions that are related to machine learning algorithm:

1. Are machine learning (ML) algorithms used to process and analyze the health data?

   a. Yes/No

   b. If yes, please mention the applications where machine learning is used

VI. General information:

1. Can I contact you directly in the future for more information, if needed?

   a. Yes/No

   b. If yes, please specify your preferred mode: Phone/Email/Skype

Thank you for your participation

Appendix C <Sample Patient Medical Form>

Patient Medical History Form

I. **General Patient Information:**

Patient Name

Patient 1

Gender

Male

Age

38

Height

158cm

Weight

55kg

Phone Number

****

Email

Patient1@gmail.com

Reason for seeing the doctor

Allergy

II.   Patient Medical History:

a.   Have you ever had (Please check all that apply)

☐ Anemia

☒ Asthma

☐ Cancer

☐ Diabetes

☐ Emotional Disorder

☐ Fainting Spells

☐ Heart Disease

☐ Heart Attack

☐ High Blood Pressure

☐ Digestive Problems

☐ Ulcer Disease

☐ Hepatitis

☐ Kidney Disease

☐ Liver Disease

☐ Thyroid Problems

Appendix D <Sample Epicrisis Document>

Epicrisis somatics (edi)

Orthopedic Department, Orthopedic Post Skien v / Senior User3 Courses / courses3.20.08.19

Admitted: 25.09.19   **Discharged:**

Inpatient:

Family doctor:

Admission reason: test

Main condition:

Other conditions that have been considered, assessed or treated during the stay:

Diagnosis

A 00.0 Pain, swelling

A01.1 Broken leg

Procedure(s):

Background

Applicable for admission

Findings and survey results

Unfinished samples are entered

Progress and treatment

Assessment and evaluation

Function level at discharge

Further follow-up

Medicines at discharge

Preparation dosage indication category in BNMC (As before, New, Modified, Cure)

Information for the patient / relatives