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Robotic Process Automation in Public Administrations

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Abstract: Against the background of current activities towards administrative modernization based on the digitalization of processes, the usage and integration of Robotic Process Automation (RPA) software into public administration work processes can significantly improve their efficiency, reduce process costs and provide better services for citizens. This paper presents and investigates the concept of RPA and discusses the particular potential and challenges of RPA in the public administration context. Furthermore, it demonstrates an application example of a new cognitive RPA approach for automated data extraction and processing that is used in a trade tax assessment scenario using deep convolutional neural networks (CNN). Based on the findings it can be concluded that RPA has considerable potential for the improvement of the efficiency of administrative work processes and for administrative modernization in general.

Keywords: Robotic Process Automation, RPA, Cognitive RPA, Business Process Management, BPM, Deep Learning, Convolutional Neural Networks

1 Introduction

One central endeavor of administrative modernization is digitalization. While the term digitalization is ambiguous, we will use this term in the sense of the process of social change and transformation, in the context of which the state and public administrations are increasingly influenced and shaped by the possibilities and challenges of digital computer technology and the Internet. Digitalization has a particular influence on the possibilities of organizing and executing work processes in public organizations as well as in the business context. Thus, the state and public administrations are also increasingly confronted with the challenges of further developing the potential and opportunities arising from digitalization for their specific needs and for the purpose of administrative modernization.

Automation is one important aspect in the context of digitizing and modernizing public administrations as well as their work processes. The term automation generally describes the execution of a procedure by a technical artefact without the need of human activity or intervention ("autonomous acting"). Automated systems are supposed to perform work processes and to solve problems. Using automated systems in the public administration context can thus support people in working more efficiently and more effectively. Many organizations are currently striving for the automation of business processes by means of

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autonomous systems. This topic is discussed under the umbrella term *Robotic Process Automation* (RPA) [ABH18] as one important concept in the context of *Business Process Management* (BPM) which specifically supports the execution phase of common business process lifecycles [HFL10, Ho11, Aa13]. While the concept of traditional or classical RPA (*rules-based* or *knowledge-based RPA*) has been around for a longer time now, especially the usage of concepts, methods and techniques from the field of *artificial intelligence* (AI) takes the possibilities of RPA to a higher level [Br18] and enables so-called *cognitive RPA* applications and, based on this, so-called *cognitive services*.

This contribution aims at presenting the potential and challenges of *Robotic Process Automation* for public administrations against the background of the current process of administrative modernization. To meet this goal, the general potential and the challenges of RPA are investigated and discussed with a focus on typical public administration use cases. Moreover, we present a cognitive RPA prototype using deep convolutional neural networks (CNN) for automated data identification, extraction and processing in a trade tax assessment scenario at the interface between tax authorities and a company, which resulted from the application of a design-oriented research approach [He04, GH13]. The *remainder* of this article is as follows: after this introduction, section two introduces conceptual foundations of Robotic Process Automation before section three presents insights into the specific potential and challenges of RPA in the public administration context. Section four presents the concept, implementation and application of our cognitive RPA prototype. Section five discusses advantages and drawbacks of RPA in general and for public administrations before section six concludes the article.

2 Conceptual Foundations of Robotic Process Automation

The term *Robotic Process Automation* generally describes a broad range of approaches and technical concepts that support the automation of repetitive activities and routine work processes in organizations [AR17]. Comparable to the substitution of physical work in manufacturing processes by robots, RPA aims at the substitution of intellectual work in office and administration processes by means of so-called software robots [SEH17, FL18]. RPA supports the realization of considerable efficiency potential and is thus a promising approach for Business Process Management initiatives in general [Cz17]. Existing RPA solutions can be stand-alone systems or can also be part of more comprehensive *Business Process Management Systems* (BPMS). Figure 1 illustrates the development of architectural designs of BPMS towards the current state, which includes dedicated RPA components (the development from the 1960 until 2000 is based on [Ho10]).

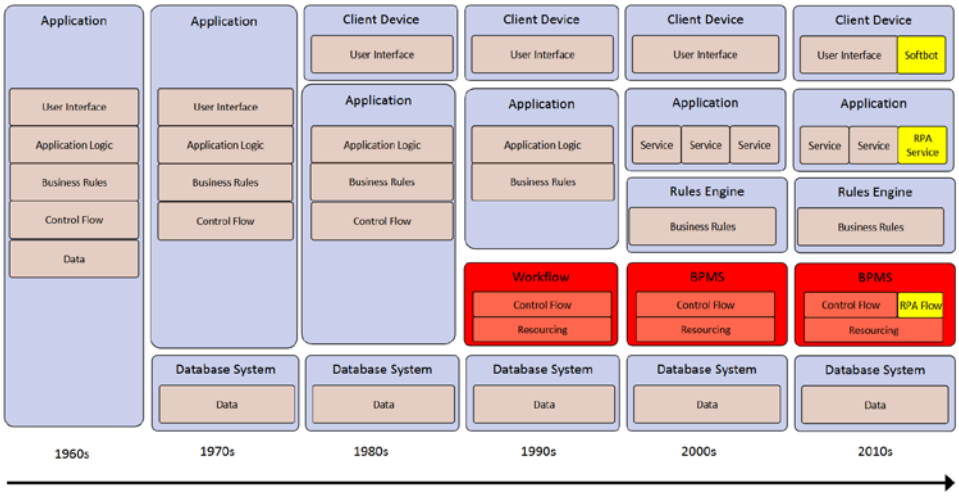

Fig. 1: The development of BPMS architectures towards the inclusion of softbots and RPA

RPA has been around for several years, but there are several important characteristics, which have led to a stronger rise of this topic in recent years and which should be mentioned when introducing the term RPA [AR17, Ki17, FL18, ABH18]:

(1.) Classical RPA does not oblige organizations to use entirely new software systems to automate their work processes, but rather builds on already running software systems, which need not be replaced. Legacy systems are extended by RPA approaches and established structures do not have to be changed in a radical way.

(2.) Classical RPA generally intends to use programs working on existing user interfaces of a software system in the same way as humans interact with a system. The requirements engineering for the development of according RPA implementations can, e.g. be realized by identifying and capturing human behavior using screen recording while interacting with a software system [CKM18].

(3.) Current innovative RPA approaches (*cognitive RPA*) make use of technical concepts and software techniques from the field of AI, e.g. in order to automatically observe and learn human user behavior based on machine learning approaches and to imitate this behavior.

In contrast to classical RPA approaches, cognitive RPA solutions are supposed to perform tasks which need stronger cognitive abilities to be executed. There are several known use cases in which cognitive RPA solutions are applied, e.g. in the context of stock portfolio management or concerning the surveillance of process compliance in banks, in the context of the automated analysis of customer requests in insurance companies or in the context of automatically answering service requests in natural language using a chat bot in customer service scenarios [Sc18, p. 195].

3 Application Potential of RPA in Public Administrations

There are typical tasks in public administrations which can be solved by RPA applications, e.g. data integration or transformation and process integration [Cz17, FL18]. Simple software robots can, e.g. execute the following tasks [De17, Sc18, p. 193f.] that are especially relevant for public administrations:

- Fill in masks, e.g. when electronically available data needs to be filled into an electronic form,
- Reading and writing in databases, e.g. when information needs to be updated in a administrative information system,
- Extract data, e.g. from electronically submitted applications or forms,
- Create reports, e.g. overviews of completed cases handled in one year in one public authority serving for performance comparisons,
- Login and access data from enterprise resource planning (ERP) systems,
- Integrate data from different information systems,
- Analyze if-then rules and follow them, e.g. in order to automatically prepare and support decisions in the context of case handling,
- Perform calculations,
- Access and process e-mails,
- etc.

Furthermore, the following sections describe typical work procedures and scenarios in the context of public administration in which RPA offers significant potential in more detail:

(1.) *Automated acquisition of data from paper documents*: Public administration processes in Germany often necessitate a paper-based application, which has been signed by the applicant's own hand in order to initiate a legally valid administrative process. In such a case, many data in the application form have to be manually entered into a data processing system by a civil servant after the application has been submitted to the public authority. This is surely a very costly activity, which serves for no extra benefit. An RPA-based approach using *optical character recognition* (OCR) techniques can be used to automatically extract the data from paper-based application forms and to automatically enter them into a data processing system. OCR-based approaches work quite effectively and efficiently in the meanwhile and can, thus, support considerable cost savings. However, the automated data extraction can also results in incorrect data depending on the representation quality of this data in the application form. If the data is handwritten, there is a higher error probability caused by the automated extraction. If this data is typewritten, the error rate should be quite low. However, in any case the data should be controlled by a human employee afterwards to avoid erroneous data acquisition.

(2.) *Automated integration of data*: Work processes in public administrations often need to make use of data from different sources, e.g. data from personal files of an appli-

cant, data from public registers such as the real property register etc. Hence, sometimes according data is spread over different public administration application systems or different databases and has to be gathered by a civil servant in order to be able to properly execute an administrative work process. In such a case, RPA approaches can serve for the integration of all relevant data from different systems into a centralized and process-related data storage holding all relevant data for the execution of an administrative process by a civil servant. In such a scenario, the RPA system can automatically maintain the data consistency in all connected and related databases. This is obviously an application scenario in which RPA can provide significant efficiency potential. However, the installation and maintenance of such automated update mechanisms can quickly become quite complex. Hence, regular monitoring of the system infrastructure is needed as well as effective and consistent management strategies to achieve and maintain a good data quality.

(3.) *Automated transformation of data*: More and more civil services in Germany can be accessed via the Internet and according application forms can be filled and electronically submitted. However, sometimes the data submitted by the citizens is needed in different application systems with different underlying database schemata. Hence, data transformation procedures are needed to prepare the transfer of the citizen data into all relevant connected systems. In this context, RPA can transform and prepare the data for the different systems. Challenges occurring in this context are comparable to those described in the section before. However, as database schemata typically remain unchanged for longer periods of time, these problems are even a little less problematic in the context of RPA-based data transformation scenarios.

(4.) *Automated integration of processes*: RPA can also support a more efficient execution of administrative processes by automatically starting the next task in a process or forwarding tasks to the organizational unit which is supposed to further work on a case in order to minimize waiting times. The underlying idea of such scenarios is commonly realized in integrated *workflow management systems* [Ma95]. However, in the public administration context it might be that there are different underlying application systems serving for the execution of one work process or that parts of a process are not at all supported by an information system. In such cases RPA can help to realize an “integrated” automated workflow management although there is no integrated information system.

(5.) *Automated decision support*: Cognitive RPA solutions can support quicker and more efficient decisions in handling application cases, if the data which is needed to decide on a case is electronically available and accessible. In this context, there are different scenarios: (1.) RPA solutions can analyze the fulfillment of formulated rules and recommend a certain decision for handling a case including the underlying arguments, which led to the recommendation for a decision (“classical decision support”). (2.) Decisions could also be made and communicated by the RPA solution itself. However, while this is a possible scenario, it is necessary to carefully choose in which cases such a fully automated process organization could be applied (“machine-

based decisions without a final human check whether the decision is accurate and justifiable").

For public administrations, which are interested in using RPA solutions, it is in any case important to identify and investigate appropriate tasks and processes [LAR18]. The above presentation of typical tasks and scenarios can support public administrations in identifying appropriate work processes. When trying to identify and choose an existing RPA solution for potential process automation projects in public administrations, the following categories can be differentiated against the background of the above introduced classical RPA concept vs. the cognitive RPA concept:

(1.) *Programmable RPA bots* in which programmers must manually define the rules that a bot is supposed to execute,

(2.) *Self-learning RPA bots* that use historical and current data to learn how a user typically interacts with a software system and mimics interactions to perform tasks automatically, and

(3.) *Cognitive RPA bots* which can learn rules from structured and unstructured data in order to perform a task automatically.

In the following section, we will present our cognitive RPA prototype for automated data identification and extraction from trade tax assessment notices at the interface between public tax authorities and companies from the companies' perspective.

4 Cognitive RPA Approach for Automated Data Extraction from Trade Tax Assessment Notices

4.1 Use case description

Working together with public administrations, e.g. in the context of determining the taxes to be paid, it is often necessary for companies to accept working with paper documents. For example, companies receive tax assessments in the form of paper-based documents, which must first be digitized in order to enable further electronic processing of the data contained. Using classical OCR procedures, there is the problem that with a complete capture of the document the semantic assignment of the individual data fields is missing and there is no possibility to categorize and classify captured data fields correctly for the further data processing. Hence, when capturing the string "19.10.2018", it is not clear which particular kind of date this is. The question is: Is this the date on which the decision was issued, or the date of the intended receipt of payment, or any other date that played a role in the formulation of a tax assessment notice?

Tax assessment notices usually have the same or at least a largely similar layout and could therefore be digitalized quite simply with existing OCR procedures, in which the relevant

data fields are fixed with a mask based on the layout. However, certain types of tax assessment notices, such as trade tax assessment notices, are issued by municipalities and differ very clearly from municipality to municipality in terms of layout. Against this background, automated data collection from the different notices with the help of classical RPA is a challenge for companies which are located in different municipalities, such as the many different stores of large retail groups. The cognitive RPA prototype presented in the following serves for automated data extraction from different trade tax assessment notices having different layouts.

4.2 Concept of the cognitive RPA prototype

The concept of the cognitive RPA prototype is based on an existing *object detection network* (YOLO2)[2] that learns to classify multiple objects in an image and reports the position of these objects in the form of ***x*** and ***y*** coordinates. In the case of object detection on documents, we defined an object as a relevant and meaningful section of the document e.g. an address field or a table with relevant content. The cognitive RPA prototype was implemented in two parts, i.e. a document classification model and an object detection model.

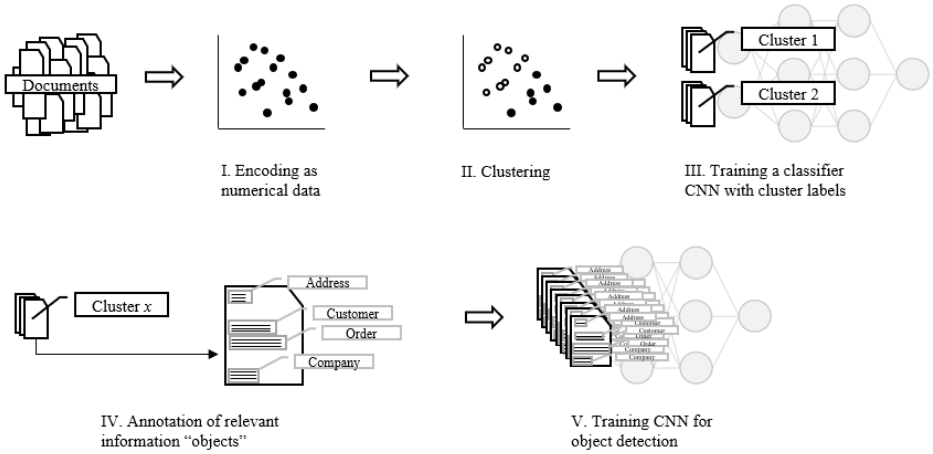

Fig. 2: Training of the document classification model, and the object detection model

The process of training the document classification model as well as the object detection model is illustrated in figure 2 and comprises the following steps:

I.) An unstructured document data set is converted to image files that are subsequently encoded as numerical data using an auto-encoder network.

II.) The numerical data is then clustered using k-means clustering to distinguish between document types.

[2] https://pjreddie.com/darknet/yolov2/

III.) A convolutional neural network is trained to classify document types labelled with their cluster number.
IV.) Within a cluster, relevant data objects are annotated with different data types (e.g. *Address, Customer_id*).
V.) A CNN is trained to detect the data objects in a document image.

After training the classification and detection models, new unseen documents can be fed into the prototype to perform an analysis and extract the relevant tax-related data. Figure 3 describes this process in which the following steps are performed:

I.) A new document is converted to image and classified by the trained CNN.
II.) Object detection is then applied to the document image using the settings for the detected document class.
III.) The class and the coordinates resulting from the object detection are used to extract snippets from the document image and label them.
IV.) Using OCR, text is extracted from the labelled image snippets. The labelled data can then be shaped in any data format, e.g. XML, CSV or JSON, for the integration into existing information systems.

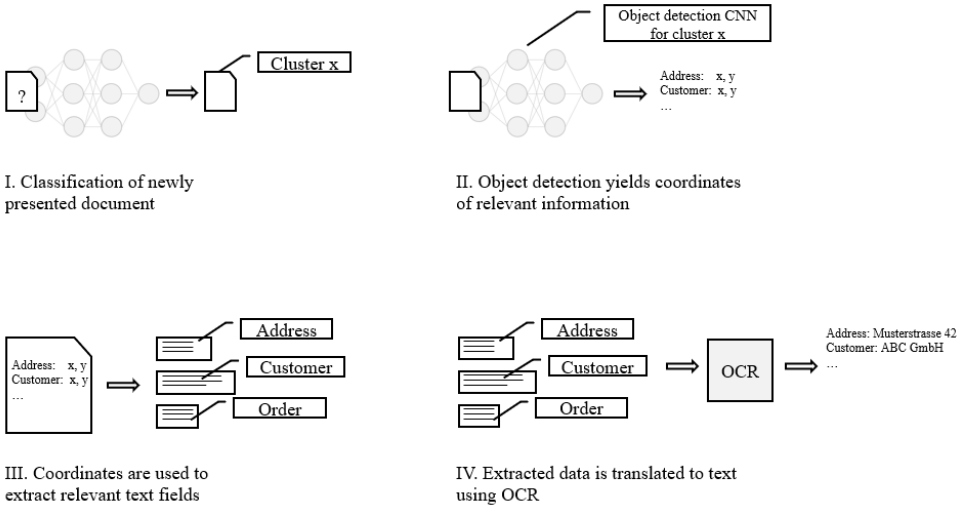

Fig. 3: Data extraction procedure

4.3 Implementation and application of the cognitive RPA prototype

To demonstrate our approach, a prototype was implemented as a *flask* web application in which a document can be uploaded to the server. Then the object detection and OCR procedures are performed. Figure 4 *(part I)* shows the "*Scanning screen*" that is shown after a document was uploaded, while the network is started and object detection is performed. After detecting the objects on the document image, the coordinates of each object are used

to cut a snippet out of the image. This snippet contains only the detected object and can be linked to its label, e.g. "*Address*" (figure 4, *part II*). The snippet is fed to the Tesseract OCR engine[3] and the resulting text is stored under the aforementioned label (figure 4, *part III*). The identified data are then automatically entered into the legacy system (figure 4, *part IV*) to further proceed the tax-related data in this scenario.

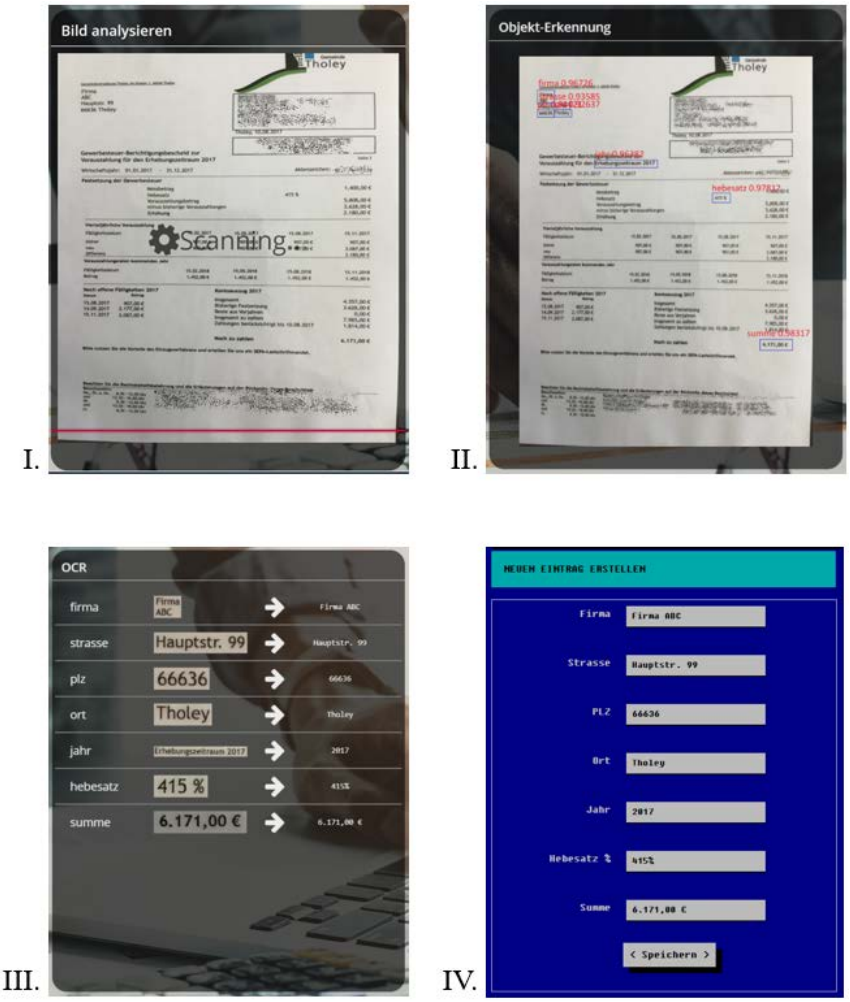

Fig. 4: Cognitive RPA usage workflow from document scan (I.), object recognition (II.) and data extraction (III.) to data entry and processing in a legacy system (IV.)

[3] https://github.com/UB-Mannheim/tesseract/wiki

5 Discussion

While the potential of RPA in typical public administration tasks as described and investigated above is quite promising and the usage experience gained from the application of our cognitive RPA prototype is also quite auspicious, there is also some critical discussion whether RPA is the right way for administrative modernization or maybe even hinders real progress [Ki17, p. 2]. Indeed, many RPA solutions are workarounds for a better integration of data and processes using legacy systems. In other contexts they support process integration where there is no integrated information system support at all. Hence, RPA solutions can successfully mitigate day-to-day problems in the public administration context and can provide realistic and down-to-earth solutions in a sector, which simply cannot afford a fundamental replacement of legacy systems with new IT infrastructure and up-to-date application software.

As already mentioned, using RPA can result in a better service delivery and, moreover, in a higher process efficiency. However, a proper quantification of actual savings is not easy, sometimes not even possible [SEH17], and while using RPA can result in fast process execution, it can also "make mistakes faster" [Ki17, p. 2]. This can end up in major problems and higher expenses, which can even outreach the benefits of the automation, if e.g. certain applications are automatically permitted, which would have been denied by a human actor. Hence, the major aspect in this context is not the automation of the process, but a proper process design that allows for a real improvement when automating the process [ALS16].

It is very likely that RPA and AI in general will have a major impact on the way civil servants will work in the future, if RPA becomes more and more accepted in public administrations. Staff will have to be "trained and up-skilled to work in higher value areas" [Ch17, p. 1] because RPA or AI solutions are likely to be in charge for certain tasks in the future. However, with the further development of cognitive RPA solutions more and more, even dispositive activities in public administration could be automated assisting civil servants in executing their work, e.g. automated decision support, and thus leading to high quality results. The future will show whether even an automated decision making will be possible and play a role in the public administration context, e.g. checking and deciding on certain types of applications.

In general, administrative modernization aims at a completely paperless electronical data exchange in work processes. If this goal is going to be achieved in the future, RPA will doubtlessly not be as relevant anymore as it is today. However, as long as paper, e.g. in the form of paper-based applications, still plays a role in administrative processes, RPA will definitely be a relevant concept with a major potential impact in the current process of administrative modernization.

6 Conclusion

Robotic Process Automation provides considerable potential for public administrations and administrative modernization in particular. We discussed the potential and obvious challenges in the light of typical tasks in administrative processes. RPA most evidently supports a higher efficiency of administrative processes. However, there are also related risks which should be considered when deciding to use RPA in public administrations. We have presented an application scenario of a cognitive RPA approach supporting automated data extraction from tax documents relevant for repetitive administrative work processes. Our approach is generally adaptable to any document and can be used in numerous different contexts in public administrations as well as in business contexts. We currently plan to further develop our approach in order to use and evaluate it in different application contexts, especially in public administration scenarios.

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