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Use of Neural Networks in the Hiring Process to Reduce Costs

Bachelorarbeit

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Kurzzusammenfassung: Use of Neural Networks in the Hiring Process to Reduce Costs

Ziel dieser Arbeit ist es, die Frage zu beantworten, ob die Nutzung von neuralen Netzen bei der Personalanstellung zu einer Kostenreduktion im Bewerbungsverfahren führt. Um diese Frage zu beantworten, wird ein neurales Netzwerk mit historischen Daten trainiert, um zu testen, ob das Netzwerk in der Lage ist zu entscheiden ob Mitarbeiter angestellt werden hätten sollen oder nicht. Die Arbeit analysiert auch die Kosten der Entwicklung des Programms sowie die Reduzierung der Kosten durch die Nutzung von neuralen Netzen. Die Benutzung des neuralen Netzes hat gezeigt, dass frühzeitig erkannt werden konnte ob ein Mitarbeiter angestellt werden soll oder nicht bei einer Erfolgsquote von über 60% und mit wesentlich geringerem Zeitaufwand als bei einem ähnlichen manuell ausgeführtem Prozess was zu zusätzlicher Arbeitsersparnis in der Personalanstellung führt. Durch diese Erkentniss ist es zu empfehlen, die Software vollständig zu entwickeln und diese auch einzusetzen. Die Arbeit zeigt, dass der Einsatz der Software greifbare und echte Reduzierung der Personaleinstellungskosten herbeiführen kann.

Schlagwörter:

Einstellungsprozess, Neurale Netzwerke, Kostenreduktion im Anstellungsprozess, Künstliche Intelligenz, Mitarbeiterfluktuation, Neuanstellungskosten

Abstract: Use of Neural Networks in the Hiring Process to Reduce Costs

Aim of this thesis is to answer the question if the use of neural networks in the hiring process leads to a reduction in cost of the hiring process. To answer the question a neural network is trained on historical data to test the hypothesis if a neural network is able to predetermine if employees should've been hired or not. The thesis also analyses both the cost of developing such a program and also the cost reduction that would come by reducing employee turnover. The neural network did successfully recognize a majority of employees that shouldn't have been hired in the first place and did it within a margin of the time that personnel would have spent on such a task. Using the previously calculated cost of the software and possible cost reduction by using the software it can be seen that using the program will lead to reduced cost. Since the data shows that the reduced cost in hiring can be achieved it is highly recommended to fully develop the software and use it in the hiring process. There seem to be little to no drawbacks and the thesis shows that there is a fungible and real reduction in costs that can be achieved.

Keywords:

Hiring Process, Employee Turnover, Neural Networks, Cost reduction in the hiring process, Artificial Intelligence, Cost of rehiring

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Contents

1. Introduction

Employee turnover is a problem that every company faces. Outside factors like the recent Corona pandemic have put additional stress on both organizations and employees. (Kaushik, Meenakshi, & Guleria, 2020) At the same time discoveries and advancements in Artificial Technology and neural networks are being made almost daily. (Society, The Royal, 2017)

The cost of rehiring employees is tremendous and being able to mitigate employee turnover and potentially reducing this cost would be beneficial. (O'Connell & KUng, 2007) This thesis will try to investigate the factors of employee turnover, analyze the cost of rehiring, the technology of neural networks and how this technology may be used to mitigate employee turnover (specifically within the company Massresponse Service GmbH)

1.1 Problems of employee turnover in Massresponse

In the past years the company Massresponse has grown significantly and the company that once only had a size of 20 employees has since grown to over 100 active employees. On average 6 new employees started working in the company in 2021 but 3.5 of them will leave the company within the first 1-6 months. As can be seen in Figure 1 There are almost as many leaves per month (in gray) as there are new hires (in Orange). Leaves in that graph are employees who left the company within their first 6 months of employment. This generates a twofold problem. On the one hand the company has to keep spending resources and energies to find new employees to fill positions that could've already been filled were it not for the early leaves. On the other hand a significant portion of the active employees have to spend their time and resources to train new employees just for them to leave a few short months later.

Figure 1 - Turnover Massresponse 2021

1.2 Goal

The goal of this thesis is to evaluate whether use of neural networks in the hiring process will lead to a reduce in costs within the company Massresponse.
For this purpose software will be designed and tested which will assist in the hiring process by evaluating whether a prospective applicant is most likely to stay in the company. This is being evaluated based on historic data fed into a neural network.
A cost comparison between the new method and the old hiring process will be compiled on predictions and past historic data (e.g. would the new system have supported the hiring of a known short term employee or not and could that have led to a reduction in cost?)
The expected outcome of the research is that a cost reduction can be observed when using the neural network and the software can be used inside Massresponse to reduce the cost of employee turnover.

1.3 Research Question

To accomplish the purpose of this research the following question needs to be answered:

Does the use of neural networks in the hiring process of Massresponse lead to reduced costs of personnel selection and rehiring?

1.4 Structure

This thesis is divided into seven main chapters: the introduction, literature review, conceptual solution, solution approach, cost of personnel selection and rehiring, results, conclusion and implications. First an overview over what neural networks and their history will be given. Followed by that a short introduction to TensorFlow will be given. In the second part of the Literature Review the hiring process, employee turnover and the cost of rehiring will be covered. Additionally there will be a description how the hiring process within Massresponse differs from the classical approach and how neural networks and artificial intelligence can be used to assist in the personnel selection process. In the next section the conceptual solution will be explained. First how the data selection process works then how the software/program will be designed. There will also be an explanation of all the variables used and finally an overview of the data and how it can be analyzed. The next section will talk about the actual solution approach. It will be described how the software was programmed, then how the neural network was prepared and trained and finally the actual processing of data through the software and its interface. The author will then look at the output and analyze and compile a final dataset. The next section will include expert interviews about the real cost of personnel selection and rehiring within Massresponse. In the next section the results of the software will be evaluated. Not only in terms of cost reduction but also a cost comparison of the creation and application of the software compared to the potential cost reduction in hiring. The author will compare and analyze the results and report their findings. In the last section the author will present their conclusion, the limitations of the whole thesis and possible practical implications.

2. Literature Review

The literature review is an overview of the knowledge for neural networks, a brief overview over Google's TensorFlow – and the practice of hiring processes. Furthermore the hiring approach within Massresponse and the use of neural networks within the personnel selection process is being investigated. Lastly the review looks at reasons for employee turnover and analyzes the cost of rehiring employees.

2.1 Neural Networks

Neural Networks were first pondered upon in the early 20th century. Donald Hebb, a psychologist, wrote a paper and later a book (The Organization of Behaviour) where he describes how neurons might work and developed a simple neural network using electrical circuitry. He wrote "When one cell repeatedly assists in firing another, the axon of the first cell develops synaptic knobs (or enlarges them if they already exist) in contact with the soma of the second cell." (Hebb, 1949)

In the 1950s Arthur Samuel, who was working with IBM at the time, developed the first computer program that could play checkers. This was also the first primitive version of machine learning. Due to extremely limited memory, Samuel had to create an algorithm that eliminated choices by selecting the "best choice" available. The design used a scoring function that evaluated the positions of the individual checkers on the board and attempted to measure the chances of each side to be victorious. This program eventually evolved into the minimax algorithm. (Samuel, 1959)

These two concepts of Hebb and Samuel were eventually merged into the *Mark 1 Perceptron* by Frank Rosenblatt in 1957. The Perceptron was a two layer network with an input and an output layer and even though it was originally designed as a custom built machine it ended up being a program capable of being run on the IBM 704, designed to do very basic image recognition. In that regard it was one of the first examples of a program that could be run on different architectures. A decade later in 1967 Alexey Ivakhnenko and V.G. Lapa built on this design and made the Perceptron into a multilayer

network using a feedforward design. This network had eight layers and was trained by the group method. (Kanel, 2003)

All these precursors led to deep learning becoming a reality in 1989 when Yann LeCun, et al. experimented with the standard backpropagation algorithm and applied it to a neural network. This was in contrast to the feedforward design that had been used previously. The goal was to train a computer to recognize handwritten ZIP codes. The new system was a success and deep learning was created. (LeCun, et al., 1989)

Unfortunately this was the end for widespread neural networks for the time being as the computational requirements of such networks were simply too high for the computers of the time. Research continued but it was simply impossible to feasibly build these neural networks with the hardware that was available. It wouldn't be until the early 2000s when computational power – particularly through advances made by NVIDIA with their GPU technology – grew to such an extend that deep learning and the use of neural networks gained widespread usage. (Oh & Jung, 2004)

A neural network is a series of algorithms that are designed to recognize relationships in a set of data through processes that are mimicking how brains operate. These neural networks are capable of adapting to changing input and the network will always try to

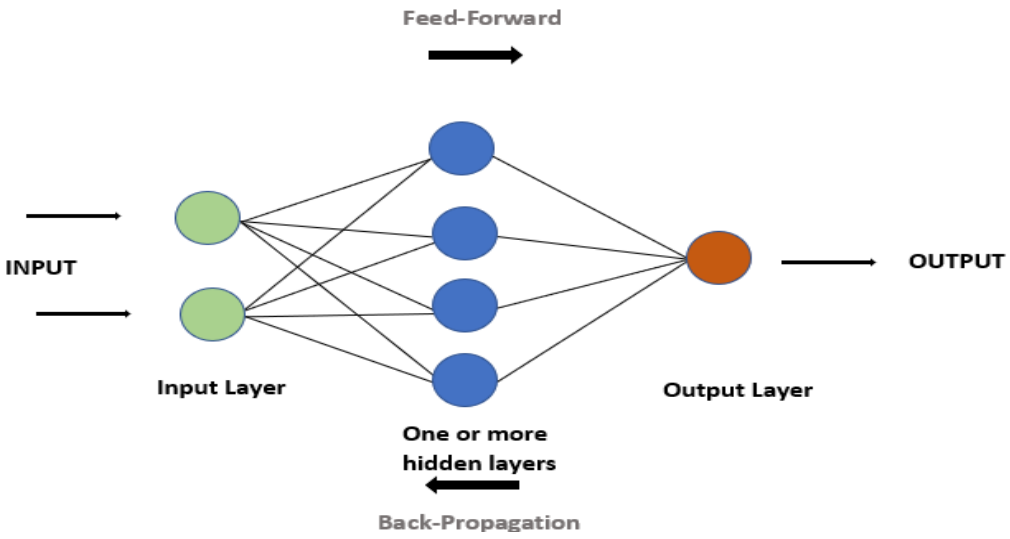

Figure 2 - Schematic Neural Network

generate the best possible result without the need to redesign any of the output criteria. (Gurney, 2018)
As shown in Figure 2 a neural network always has an Input layer and an output layer and one ore more hidden layers in between.

2.2 Tensor Flow

TensorFlow is an open-source platform designed by Google in order to create machine learning applications. It was originally made public in 2015. The first stable version was released in 2017. Developed by Google, the TensorFlow platform is used within Google itself to improve their search engine, translation tools, image captioning and recommendations. TensorFlow is a symbolic math library that uses dataflows and programming to perform a variety of tasks that focus on training and usage of deep neural networks. The TensorFlow platform allows developers to create applications for machine learning using different tools, libraries and resources. It enables users to build dataflow graphs and structures to define how data moves through a graph. This is done by taking inputs as multi-dimensional arrays called “Tensor” (Hence the name). The framework allows you to construct a flowchart of operations that can be performed on those inputs which go in at one end and come out at the other end. The TensorFlow architecture works in three parts – Preprocessing data, building a model and training and estimating a model. (Abadi, et al., 2016)

2.3 Classical hiring processes

The classical hiring process can roughly be split into four parts - recruitment, selection, orientation, employee development.

Recruitment is the process which involves the attraction of people who are potential candidates that will be chosen by the organization to work in specific departments. This process involves communicating with actual or potential job seekers, inviting them to apply for the position and trying to convince them to work for the organization. (Falcone, 2002)

Selection happens after Recruitment and involves choosing who to hire from a preferably large pool of applicants. The selection process itself can be further broken down into the following steps:

1. Initial interview (Screening)
2. Application form
3. Comprehensive interview
4. Background/security check
5. Medical check
6. Final job offer

In many cases background and medical checks are not necessary and sometimes there are a series of interviews involved instead of just two or the interviews are condensed into just one. Each of the steps described represents a decision point requiring some affirmative feedback for the process to continue. This affirmative feedback must come from both sides – the applicant and the organization as both of the parties may decide against moving ahead in the selection process. (Kamran, Dawood, & Bin Hilal, 2015)

The next step in the hiring process is orientation. In this step the new employees are introduced to the organization, their work units/departments and their jobs. Orientation is usually given by co workers or trainers within the organization and depending on the orientation program used it can have immediate and long lasting impacts on new employees which in turn makes the difference between success and failure. (Whiddett, Kandola, & Keenan, 2000)

The last step in the hiring process is employee development. Employee development, in contrast to employee training, is more future oriented and greatly concerned with educating. Development focuses on planting a sound reasoning process in employees and enhances their ability in understanding or interpreting knowledge rather than imparting mere facts or teaching just a set of skills. As such, employee development ideally never ends as employees, no matter what level they are, can always be developed. (Barnerjee, 2006)

2.4 Employee hiring approach within Massresponse

Massresponse follows tightly in the footsteps of the classical hiring process. Massresponse does not do any background or medical checks. However, additionally to the steps of the traditional hiring process an online questionnaire and a programming aptitude test are used to further filter down the applicants. The online questionnaire is part of the initial screening process while the programming test happens later in the process as can be seen in Figure 3.

From recruitment to job orientation the whole hiring process takes approximately 1 month. Each individual step of the process until job orientation takes between 1 and 2 hours during which at least one HR employee and up to 2 employees of the respective concerned department will be involved. The final step of job orientation usually spans over the whole first month of employment while employee development starts immediately thereafter and goes on indefinitely. Every employee is assigned a mentor which will spend an average of 2 hours per day of actively training/instructing new employees during their first month. This process continues well into the employee development stage but the effective time spent will decrease significantly over time. For the purpose of this study we're looking at the first 6 months of employment and after the first month the average additional time spent on new employees is approx. 3 hours per work week. (see Appendix 1).

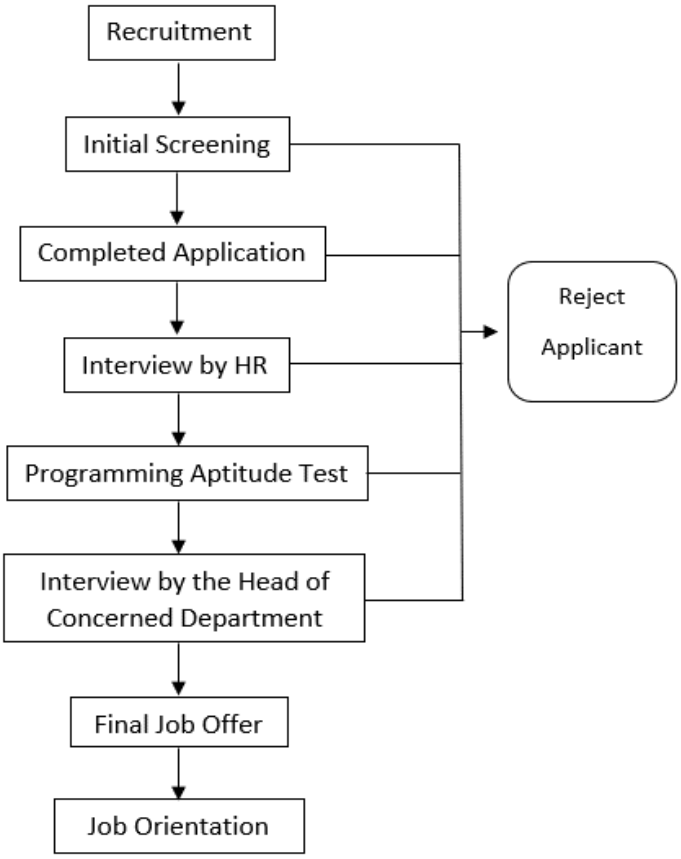

Figure 3 - Massresponse hiring process chart

2.5 Use of neural networks in the personnel selection processes

Computer programs in the past that were used for recruitment and hiring were trying to mirror the classical hiring process. Instead of paper tests computer based employment tests were used. Application processes were automated where possible and internet job boards, applicant tracking systems and hiring related web sites accelerated the whole hiring process while still replicating most paper based procedures. (Scarborough & Somers, 2006)

Networked computers and neural networks in particular are revolutionizing the employee selection process. A relatively new and important capability is the possibility to have statistically informed hiring decisions over networks. Centralized, standardized and measured hiring practices in a way that was impossible using a traditional pen and paper approach. Online job seekers benefit from a uniform application process and evaluation process, which can improve their access to career opportunities because they don't have to contend with physical proximity issues or office-hour time constraints. Using online hiring systems allows for the collection of large amounts of data at a low cost for employee selection validation studies. A closed-loop system is created when applicants, hiring decision support systems, and employee performance databases are integrated. Selection research data elements are captured organically (in the normal course of hiring and terminating employees) and used to populate a comprehensive data warehouse of applicant and employee records. (Scarborough & Somers, 2006)

The idea to use neural networks and artificial intelligence to assist in personnel selection then was only natural. (Gargano, Marose, & Von Kleeck, 1991) There are two major ways neural networks are used to achieve the best results. One method is data mining and the process of reducing potential employees to a data set. These data sets can then be classified and compared and a neural network can be trained and used to deduce whether or not an employee should be selected. The other method has a more psychological background. Neural networks are trained to look for certain psychological responses and traits using image recognition and recorded interview sessions. Applicants are essentially recorded during their interviews and the footage will be analyzed using artificial neural networks to determine whether candidates are fit for the job or not. For example neural networks can determine how nervous a person is based on their facial expressions and postures. (Van Esch & Stewart Black, 2019)

2.6 Reasons for employee turnover

Rising turnover rates of highly educated employees is a growing phenomenon. It can be summarized as a rotation of employees between companies, positions, and employment/unemployment circles. More statistically speaking “Turnover is the ratio of

the number of organizational members who have left during the period being considered divided by the average number of people in that organization during the period." (Ongori, 2007)

Employee turnover can be classified into two groups – voluntary and involuntary. The difference between the two is that the reason for involuntary turnover cannot be influenced by the management or the employee themselves whereas voluntary turnover is chosen willingly by the employee. (Ongori, 2007)

The cost of employee turnover can be as high as 400% of the annual salary (Greenberg, 2011) of the employees and turnover has therefore an enormous impact on the profit and productivity of the company (Blomme, Van Rheede, & Tromp, 2010). The disturbance of changing colleagues in the work environment slows down efficiency because remaining employees must get used to new colleagues and also need to cover tasks while filling up the vacancies. The cost of employee turnover consists of many different expenses (see Figure 4) (Boella & Goss-Turner, 2019).

Many possible reasons lead to employees wanting to quit their job. There is no clear consensus about the main driving force behind employee turnover but there is some degree of overlap between different experts. A majority of all quoted reasons lead back to job related stress and lack of commitment towards the company and so employees are motivated to quit their job and if their desire grows strong enough they will.

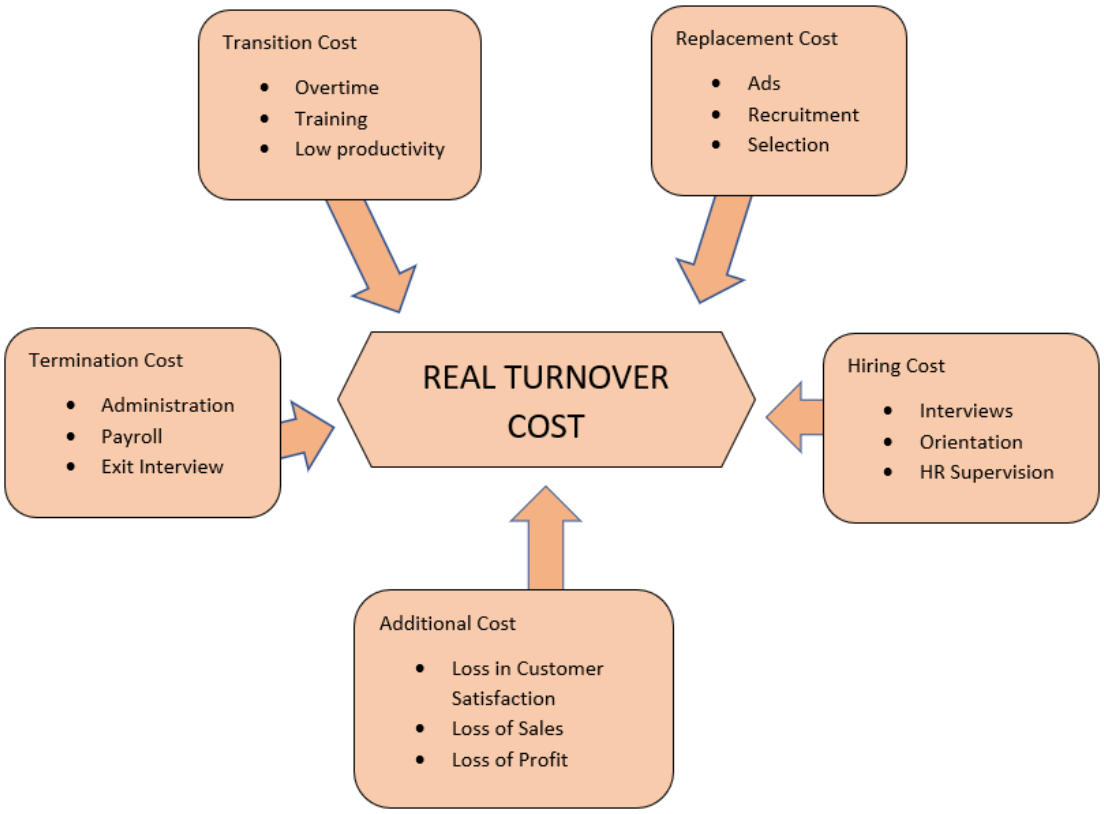

Figure 4 - Real cost of Turnover (Boella & Goss-Turner, 2019)

Eight major reasons can be isolated that will lead employees to quit their jobs (Maertz Jr & Campion, 2004):

- The affective force which is a psychological phenomenon most often triggered by anxiety. Depending on the trigger which can either be emotionally positive or negative this can reinforce employees to want to stay in the company but also in them deciding to quit their job (Maertz Jr & Campion, 2004)
- The contractual reason which is based on the theory that employees have perceived expectations about their companies. If these expectations are not fulfilled the employees will think about quitting their job. (Maertz Jr & Campion, 2004)
- The constituent force which considers that employees differentiate between a relationship to the organization itself and to the colleagues with whom they work in the organization. These relationships are not connected. Either can lead to the employees wanting to quit. (Maertz Jr & Campion, 2004)

- The alternative force is basically the idea that there are plenty of other job opportunities out there and if the employee thinks that these opportunities are superior to the current job they will try to quit. (Maertz Jr & Campion, 2004)
- The calculative force states that employees will calculate their future chances inside the company. If they cannot find a goal inside the company, they will also feel urged to quit. (Maertz Jr & Campion, 2004)
- The normative force considers the perception of private environments like friends and family and the reputation of the organization toward the outside. Depending on that reputation employees may also want to leave their current positions. (Maertz Jr & Campion, 2004)
- The behavioral force relates to the fact that employees want to avoid any psychological cost. For example, employees want to avoid the feeling of many wasted years of working in a company and prematurely leave the company to escape that cost. (Maertz Jr & Campion, 2004)
- The moral force is a trigger that keeps people from leaving their jobs as quitting a job is often associated with a weak character. However this feeling is often easily overpowered by any of the other driving forces. (Maertz Jr & Campion, 2004)

All these forces are of non-monetary. They are of psychological nature and can be applied to every organization. In addition to these psychological forces, money can also be a driving factor to leave a job. In the IT industry specifically, people are often overworked and underpaid and since personnel demand is high it is often easier to leave your current job for another. (Kanwar, Singh, & Kodwani, 2009)

2.7 Cost of rehiring

As previously mentioned employee turnover has a higher cost than may originally expected. (Boella & Goss-Turner, 2019) A big part of that cost comes from the cost of hiring or rather rehiring due to turnover. The Society of Human Resource Management estimated in their 2016 Human Capital Benchmarking Report that companies spend on average 42 days and a total of $4129 (USD) to fill any given position. (Society for Human Resource Management, 2016)

Finding a suitable person to fill a position can be difficult. There are potentially high costs in just the process of recruitment alone. These include advertising the job opening, time cost of internal HR and other recruitment-related tasks, time cost of the people conducting the interviews, drug screens and background checks (where applicable) and possible preemployment assessment or aptitude tests. (Bliss, 2000)

Once the right person is in place, organizations need to provide adequate training in order for employees to be able to do their work and start producing for the company. Training turns out to be one of the costliest investments a company can make. Companies spend an average of $1286 (USD) per year per employee (2019). (Peterson, Song, & Udell, 2019)

The most obvious cost of new employees – their salary – usually comes with its own bundle of side items. Benefits can range from free coffee in the office kitchen to life insurance, tuition reimbursement and company cars. The estimated additional cost of benefits is usually between 1.25 to 1.4 times the base salary. (Hadzima, 2005)

Workplace integration is a seemingly minor point that is often overlooked. Businesses are looking at more than simply providing a computer and an ergonomically designed desk chair. The cost of physical space, Software, cellphone, travel and any special equipment or resource required for the job. This cost has only gone up during the recent Corona pandemic as now companies do not only need to supply these items in the work office anymore but often additionally for the home office environment as well which sometimes more than doubles the cost due to insufficient Internet connectivity or other shortcomings. (Boland, De Smet, Palter, & Sanghvi, 2020)

3. Conceptual Solution

This section of the thesis is trying to model a conceptual solution to the research question. It will be explained how the data collection process works, how the software will be designed and how the data will be analyzed.

3.1 Data Collection

Every new employee in Massresponse has to go through an initial selection step. There is a standardized questionnaire which will attempt to evaluate their skills and knowledge. Additionally every applicant will have to submit their CV. In order for all data to be uniform we can directly interface into the database of the online questionnaire. However, since the CVs of each applicant are individually formatted we will have to extract relevant data and manually input it into our previously mentioned database. Information inside a CV that cannot clearly be assigned into the database will be discarded. Some data fields will be empty if the CV doesn't contain information to fill it. This creates a small additional margin of error for our neural network but the only way to mitigate this would be to let applicants fill out an additional form in lieu of their CVs. A short survey has shown that applicants prefer to send in their own CVs rather than supplying this information in a separate form on the website. (see Figure 5)

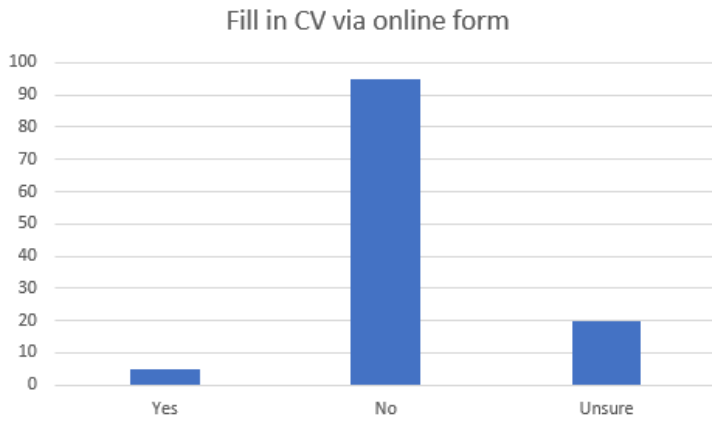

Figure 5 - Survey CV input

Once all data has been collected we can feed it into our neural network. Each individual dataset will also contain additional manual data that will help the neural network decide whether an applicant should be hired or not.

3.2 Software Design

The Software part of the Solution consists of two parts. There will be a TensorFlow deep neural network and a User Interface that serves as an Interface between new datasets that are to be checked against the trained model and TensorFlow which will do the actual checking.

In order for the network to be trained more suitably the available data is not quite sufficient and data will be synthetically generated based on the input data available. Essentially a short script will be implemented that will take the existing datasets from the database and generate synthetic additional datasets similar to the existing ones. (Le, Baydin, Zinkov, & Wood, 2017)

The User Interface part of the software will allow the user to select an applicant and a button can then be clicked to send this applicants data to the neural network where it will compare the dataset to the trained model and will then analyze the data against the trained model. The result will be a number between 0 and 1 (e.g. 0.631) where 0 means the neural network estimates this person to not be suitable for Massresponse and 1 meaning the neural network estimates the person to be a perfect match.

Both, the TensorFlow part of the software and the User Interface will be written in C# using Microsoft Visual Studio and the extensive User documentation of both TensorFlow and C#. (Joost, Rigal, Wijnholds, Van Eck, & van der Leek, 2016)

3.3 Data Analysis

First it will be determined what the actual cost of Rehiring an individual person within Massresponse entails. Expert interviews will be conducted with HR personnel and accounting personnel within Massresponse respectively to evaluate the actual cost of Hiring employees within the organization.

Historic data will be used to measure the success rate of the neural network approach. For example a historic dataset of an employee that prematurely left the company will be tested against the neural network and whether the network would have advised against employing that specific person. There is one big caveat of course because simply knowing that a certain employee wouldn't have been hired doesn't automatically mean that the company would have saved the cost. Instead it can be assumed that this calculated cost saving is a potential saving for the company. However, through the previously mentioned expert interviews we will also try to determine whether an automated additional step of the selection process like the neural network can potentially save HR effort for each individual application processed. In that case that wouldn't just be a potential saving but a true measurable cost saving for each and every applicant processed.

To be able to properly evaluate whether the use of neural networks does indeed reduce the cost it must also be evaluated what the cost of the development of this neural network is and compare it against the potential and actual cost reduction determined earlier. The cost of software is a variable that can most easily be calculated by multiplying the development hours spent and the cost of a single hour of development. This calculation will also be made and compared against the cost. Naturally the development of such software is a one off cost while the potential and actual cost reduction of using the software is open-ended. (Hareton & Fan, 2002)

4. Solution Approach

4.1 Programming and automated hiring aid

Rather than developing a fully fledged software solution I decided to program just a proof of concept instead using rudimentary scripts and tools only. Since TensorFlow is originally developed for Python, I also used Python to program the individual parts of the solution. These basic scripts and tools can later be turned into a software suit that will automate and connect all the processes in between. The first step is to take all CV data and turn it into a format that TensorFlow can understand, which in this case is a comma separated csv file (see Figure 6).

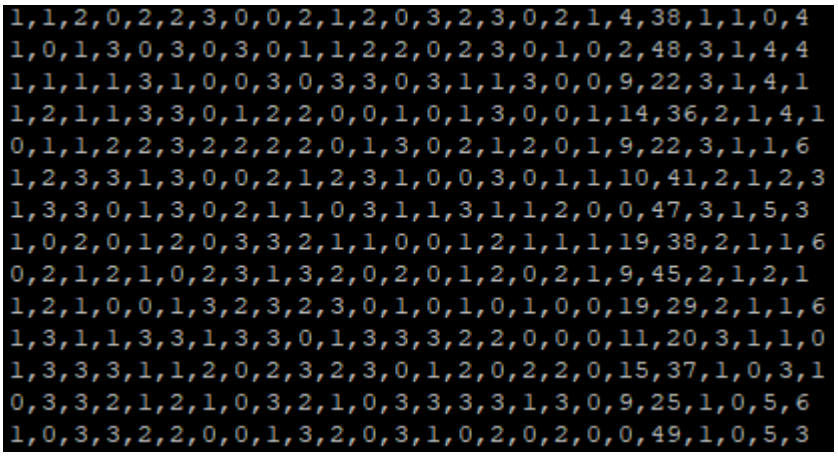

Figure 6, Sample lines from normalized csv

The values in each column are normalized Integer values based on the following anonymized input data:

- Answers to the multiple choice entrance exam
- Sex of applicant
- Age of applicant
- Level of education
- Marriage status
- How many children does the applicant have
- Additional programming skills

In Massresponse we receive on average 13 applications per month. I was able to parse past applications from the last 3 years for a total of 470 applications to work with. With the help of HR we then manually marked every dataset with a flag (isWanted) which was based on both – previous HR decisions about hires but also on employee turnover (i.e. employees that left the company within a year of being hired). In order to improve neural network training I knew that having more than 470 datasets was beneficial so I wrote a small script that generated additional training data based on the 470 datasets I had (using approx. 0.01% variance in the data itself) to multiply my data by a factor of 10.

4.2 Training and preparation of neural network

As previously mentioned Python was used for the creation of all Scripts. The following three libraries had to be installed and included:

- TensorFlow – the library to include all the necessary functions for the neural network to train and evaluate data
- Numpy – This library was necessary to put the data in an easier to parse format (numpy arrays) which TensorFlow can work with
- Pandas – This library is an analysis and manipulation tool which was used to import and prepare the csv data

I split my data into three files. The first 4000 lines became the initial training data. 600 more lines became additional training and the last 100 lines were my test data to test if the program could feasibly proof the hypothesis of this thesis.

The first step of the script was to read the csv files into memory. An instance of pandas was used for this part. The data is read into memory and split into features and labels (All features are treated identically in this stage – to prevent possible bias it is also possible to put a weight on individual features later on). The label was essentially only the ‘isWanted’ flag.

Once features and labels are separate the features are turned into a numpy array.

TensorFlow allows different methods to train its model. For a simple single Tensor input with only one output the best method to use is the sequential model called ‘keras.Sequential’ (see Figure 7).

```
employee_model = tf.keras.Sequential([
  layers.Dense(64),
  layers.Dense(1)
])

employee_model.compile(loss = tf.keras.losses.MeanSquaredError(), optimizer = tf.optimizers.Adam())
```

Figure 7 - Preparation of keras.Sequential Model

Before we can start with the actual training we also need to define an Estimator input function. It defines datasets, batches and can perform operations like shuffling (see Figure 8)

```
def est_fn(tfrecords_path):

  dataset = (
    tf.data.TFRecordDataset(tfrecords_path)
    .map(parser)
    .batch(1024)
  )

  iterator = dataset.make_one_shot_iterator()

  batch_feats, batch_labels = iterator.get_next()

  return batch_feats, batch_labels
```

Figure 8 - Estimator input function

And we also need to define what kind of Estimator we want to use. In our case we only have one output so we use a linear classifier (i.e. ts.estimator.LinearClassifier).

Now all components are set up and we're ready to do the training (see Figure 9)

```
classifier = tf.estimator.LinearClassifier(feature_columns=batch_feats)
classifier.train(
    input_fn=lambda: est_fn("tf/records"), steps=5000)
```

Figure 9 – Training

After this step we do the exact same setup but this time for our additional training data (600 datasets). Instead of training we use evaluation in the last step. Here we can actually see the first promising result (see Figure 10) as the outcome of the evaluation showed that the model was able to predict 64% of all additional training datasets.

```
INFO:tensorflow:Evaluation [2/10]
INFO:tensorflow:Evaluation [3/10]
INFO:tensorflow:Evaluation [4/10]
INFO:tensorflow:Evaluation [5/10]
INFO:tensorflow:Evaluation [6/10]
INFO:tensorflow:Evaluation [7/10]
INFO:tensorflow:Evaluation [8/10]
INFO:tensorflow:Evaluation [9/10]
INFO:tensorflow:Evaluation [10/10]
INFO:tensorflow:Inference Time : 0.74609s
INFO:tensorflow:Finished evaluation at 2022-04-10-20:49:12
INFO:tensorflow:Saving dict for global step 100: accuracy = 0.643154, accuracy_baseline = 0.620625,
```

Figure 10 - Evaluation Step

4.3 Execute program on historical and current data

Now it was time to use our trained model on completely new data. The parsing of the csv was basically the same like the setup of the training data with the difference that there was no ‘isWanted’ label for the neural network to check against.

The tf function that was used for this step is aptly named ‘predict’. I set it up to iterate through all 100 datasets and exported the result to a CSV file. I was not only interested in the actual guess the neural network was giving (wanted or not) but also its likelihood (e.g. Result is wanted and the likelihood is 70%). I then took the data and expanded it with the data the neural network didn’t have access to, in order to be able to evaluate the results (see Figure 11).

res_a	pct_s	Wanted	Not Wanted	Reallife Match
0	91		x	x
0	95		x	x
0	92		x	x
1	75	x		x
0	74		x	x
1	74	x		x
1	81	x		x
0	80		x	
0	82		x	x

Figure 11 - Output of evaluation

4.4 Analysis and evaluation of data

The final evaluation showed that the neural network chose correctly based on historical data in 64 out of 100 cases. When investigating the results I encountered an interesting aspect. The neural network's correct picks percentages were never lower than 50%. However, some of its incorrect picks were. I filtered out all results with a probability of under 50% and found that 7 results matched this criteria. 64+7=71. This means that the actual error rate of the neural network was 29% and in 7% of all cases additional human interaction would've been necessary (see Figure 12).

res_a	pct_s	Wanted	Not Wanted	Reallife Match
0	40		x	
0	42		x	
0	44		x	
1	46	x		
0	48		x	
1	49	x		
0	50		x	
1	51	x		
0	54		x	
0	55		x	
0	59		x	
1	61	x		

Figure 12 - Border cases requiring additional human input

I was also interested in whether a decision to keep or discard an applicant made a difference. Analyzing the cases, the neural networks decisions were more correct in cases when an applicant should've been refused. In fact the rate of success increased by 25% when only looking at these cases. Since refusing applicants could potentially decrease the employee turnover all of these results looked very promising.

5. Cost of Personnel Selection and Rehiring

5.1 HR Expert Interviews

The aim of the expert interview was to understand why employees leave the company and what cost that ultimately presents to the company. The interview questions were categorized into three sections. Each of the sections has a purpose and is supposed to collect as much information as possible.

- Reasons of employee turnover
- Cost of turnover/rehiring
- Possibility of turnover reduction and cost savings

In order to get a better understanding of the cost of employee turnover I interviewed the head of HR and another regular HR team member of Massresponse. The most obvious question was what the main reason for employees was to leave their jobs. HR thinks that the reason for employees to leave the job are most likely because they don't feel appreciated and possibly undervalued and that they don't get enough chance to grow. When asked what could be done to reduce the turnover they both agreed that an improvement in work environment, a higher pay and other incentives like bonuses or perks would be most useful.

Looking at the numbers I was able to ascertain that an employee prematurely leaving the company will cost the company approx. 5000 EUR to rehire said employee and on average 3 months of training to be able to fully replace their predecessor. This was just the cost of rehiring the employee. When asked about the cost for the HR department itself the head of HR estimated the cost to be about 1000 EUR per month on recruitment and extra training.

Both interviewees agreed that a possible way to reduce employee turnover would significantly reduce cost. Cost would also be reduced significantly if the workload of the HR department could be alleviated.

The head of HR also emphasized that it wasn't just the cost of recruitment and training but also a significant loss in productivity throughout the company when employees leave that would in turn cause extra strain and cost on the whole company.

6. Results

6.1 Evaluation of new hiring software

The results of the final analysis and evaluation of the proof of concept showed that neural networks can recognize potentially unwanted employees and assist in the hiring process. In its current state the solution is not user friendly and can't be used by HR employees. The Scripts and processes do exist but they would require assistance from the development team which would cause additional workhours and workload to multiple departments.

I estimate that turning the proof of concept into usable/fully automated software would require approx. 1 ½ to 2 months of development using a small development team of 1 or 2 employees.

The resulting software would be able to fully automate the process using already existing databases/resources that are currently being utilized in the hiring process.

Essentially the software would be able to give a recommendation of whether or not the hiring process should continue after the initial online quiz (i.e. before the first interview).

One important point that has to be taken into account when looking at neural network powered software is that it keeps evolving. With every employee hired and the 'wanted' flag added to their records the neural network keeps learning and improving.

6.2 Cost comparison

First let's look at the cost of developing the Software. I'm estimating 2 month development time using 2 developers. Assuming each developer spends half of their work time programming, a rough estimate would be:

4 hours/day * 20 work days * 2 months * 2 developers = 320 development hours

Assuming that these development hours would otherwise be marketable (worst case scenario) I'm valuing each development hour at 100 EUR (after tax) which would put the total development cost at 32 000 EUR.

The cost of rehiring on the other hand is based on approx. 1.5 leaves per month (see Figure 1) and estimated based on expert interview data we arrive at the following sum:

1000 EUR HR training + 5000 EUR rehiring cost * 1.5 = 8 500 EUR/month

Since the development cost is ultimately a one off cost we can calculate if and when the software would pay for itself.

32 000 EUR / 8 500 EUR/month = 3.75 months

This is a very rough estimate but it clearly shows that the possible benefit far outweighs the potential cost of the Software.

6.3 Findings

When looking at the final results of the Software evaluation process (see Appendix III) it looks very promising. Taking into account the potential benefit for the company and putting it up against the estimated cost of the Software it becomes clear that the use of a neural network in the hiring process is an option that should at the very least be seriously considered.

If the neural network is blindly used in the process (i.e. Applicant finishes their online portion of the interview and the neural network has final say over their application and denies it) it could be problematic but as long as the neural network portion (i.e. the HireBot/Helper) only gives a percentage recommendation to the HR personnel and the software is essentially an additional tool to assist in the process (thereby also reducing the HR workload) it is advisable to adapt the proof of concept into the actual software and start using it.

7. Conclusion and implications

7.1 Conclusion

In the last chapter of this thesis, the findings of the research question will be presented. The aim of the research was to find out if the use of neural networks in the hiring process will lead to a reduction in cost of personnel selection and rehiring.

Employee turnover and retention but also its cost is discussed in great detail by many researchers in the human resources sector. Employee retention strategies are extremely important for any company.

Research also shows that neural networks have reached a point where they can be used for almost any purpose and the power of modern computers allows to do this without spending an exorbitant amount of time and money on huge mainframe computers.

When using these modern neural network approaches with a dataset of applications in a proof of concept it turned out that the neural network can indeed make proper decisions based on historic data which eventually lead to a reduction in cost in the personnel selection process and an overall decrease in workload and cost in the HR department.

Applying this proof of concept into a fully developed software and using this software will also inevitably lead to an improved neural network accuracy which only increases and improves the efficiency and therefore savings that the software will ultimately be able to achieve.

Estimates show that there is a significant amount of money that can be saved which would render all possible development cost negligible within a short amount of time (approx. 4 months).

Additionally even if the savings in rehiring and training cannot be reduced to this extend the work load on HR itself can definitely be reduced and given the cost estimate of 1000 EUR per month even without the savings in rehiring and training the use of the software would eventually lead to a reduced cost of personnel selection and rehiring.

Even if the neural network cannot prevent employee turnover at all (which is very unlikely), the reduction in overall cost would be achieved regardless because the cost of the software is a onetime investment while the work load and additional cost on the HR department is a recurring cost.

The research question of this thesis asked:

Does the use of neural networks in the hiring process of Massresponse lead to reduced costs of personnel selection and rehiring?

The final concluding answer to the question is “Yes, use of neural networks in the hiring process of Massresponse leads to reduced costs of personnel selection and rehiring!”.

7.2 Limitations

Even though it could be shown that the neural network was able to predict whether the choice of an employee was beneficial to the company or not it’s impossible to say how much the company would actually save using the Software, since not hiring one person doesn’t necessarily mean that hiring another person instead will definitely lead to a different outcome.

Another possible limitation of the software is that the software itself could easily develop a bias based on certain criteria like gender and age. For example currently over 90% of all employees in the company are male and therefore the neural network could incorrectly assume that being female is one of the criteria that wouldn’t be a good match for the company and always chose against them even if every other criteria would match perfectly.

To circumvent this problem it is possible to introduce weights into the features that the neural network analyses. These weights can always be adjusted and refined. This can be included in the final software via simple sliders. It is possible that the bias is something that HR or management actively seek so eliminating these features from the selection process entirely may not be a wanted feature and ultimately limits the software and neural network.

Employee turnover that naturally occurs will also not be able to be caught by this software so a 1:1 cost saving will most likely never happen, meaning that the previously made calculations will probably never match up entirely to reality.

7.3 Practical implications

Given the fact that A.I. is developing so fast and the success of this project in particular it is easy to wonder whether in the future A.I. will take over more and more parts of tasks that are currently being done by people. Even though reduced costs of personnel selection and rehiring can be achieved it could be argued that this eventually may lead to employees becoming obsolete altogether.

For example let's assume the proof of concept (after being developed into a fully featured version) alleviates 10% of the workload in HR it could be argued that this means that for every 10 people working in HR the software turns 1 of them obsolete. In turn the company doesn't need to hire them and the job market is losing positions. This is a real problem that isn't limited to this use case but it's a practical implication that is definitely worth being looked into since a reduced total workforce can influence the entire job market and could have grave economic repercussions.

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Appendix I

Company poll - Time spent on employee mentoring

Mentor (Anonymized)	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11
A	5	2	1	3	6	3	4	5	4	0	0
B	4	6	2	1	0	6	5	2	3	1	0
C	5	4	5	6	3	4	0	0	6	5	0
D	6	0	2	6	5	4	4	6	5	4	6
E	3	3	1	3	1	3	5	1	3	6	6
F	2	0	3	2	1	1	4	0	4	4	2
G	5	1	3	5	1	0	5	5	3	6	1
H	4	6	4	0	1	4	2	1	3	5	5
I	5	3	0	2	5	3	1	4	5	3	2
J	6	2	6	1	2	4	6	0	6	2	3
K	2	5	5	3	4	6	0	3	6	6	2
L	4	4	2	1	5	6	6	0	2	5	5

Average hours/week 3.26

Appendix II

Transcript of Interviews

Interview 1

Interviewer: Guten Morgen. Danke dass du dir für das Interview Heute Zeit genommen hast.
HR employee: Klar, kein Problem
Interviewer: Ich habe ein paar Fragen zu Mitarbeiterfluktuationen. Was sind deiner Meinung nach Gründe warum Mitarbeiter ihren Job verlassen?
HR employee: Das kann viele Gründe haben. Ich denke der Hauptgrund ist vermutlich weil die Mitarbeiter sich nicht wertgeschätzt fühlen. Sie denken dass ihre Arbeit nicht genug geschätzt wird und ihnen keine Gelegenheit gegeben wird zu wachsen.
Interviewer: Verstehe. Denkst du dass es andere Gründe geben könnte?
HR employee: Ich glaube ein weiterer wichtiger Grund ist die Umgebung in der sie sich befinden. Wenn die Firma einfach nicht passt und man mit den Leute mit denen man zusammenarbeitet nicht gut Arbeiten kann, führt das bestimmt dazu dass man die Arbeit verlassen möchte.
Interviewer: Danke für die Antwort. Was kann die Firma deiner Meinung nach tun um diese Mitarbeiterfluktuationen zu verhindern?
HR employee: Es ist extrem wichtig dass man dafür sorgt, dass Mitarbeiter sich geschätzt und zugehörig fühlen. Ich denke es ist auch wichtig den Mitarbeitern die Möglichkeit geben in ihrer Arbeit zu wachsen und sicherzustellen, dass die Arbeit zu ihnen passt.
Interviewer: Wie teuer kommt es der Firma, wenn Mitarbeiter früh die Firma wieder verlassen?
HR employee: Das ist sicherlich immer unterschiedlich aber ich würde sagen es kostet der Firma eine Menge. Da ist ja nicht nur das Geld was für Recruitment und Training verbraucht wird sondern auch die Produktivität die verloren geht wenn Mitarbeiter gehen. Teilweise ja mitten in einem wichtigen Projekt das muss dann von anderen getragen werden, die oft nichtmal wissen worum es genau geht.
Interviewer: Verstehe, das macht Sinn. Deiner professionellen Meinung nach würde es der Firma also viel Geld sparen, wenn wir die Mitarbeiterfluktuation senken könnten?
HR employee: Ja, das würde der Firma definitiv eine Menge Geld sparen.
Interviewer: Kannst du mir sagen wie viel Extraausbildung notwendig ist um neue Mitarbeiter anzustellen? Also wie viele Monate zB.
HR employee: Das kommt auf die Position drauf an aber durchschnittlich würde ich von ein paar Monaten ausgehen.
Interviewer: Also würden sich natürlich auch die Ausbildungskosten verringen, wenn wir die Mitarbeiterfluktuation senken?

HR employee: Ja, sicher sogar.
Interviewer: Danke. Ich habe noch eine Frage zu deiner Abteilung selbst. Wie viele Stunden Arbeit verursacht diese Mitarbeiterfluktuation und wieviel Geld kostet das?
HR employee: Ich habe leider keine genauen Zahlen aber wir verbrauchen auf jeden Fall extra Zeit und Training bei der Anstellung von neuen Mitarbeitern. Und ich glaube es ist weit mehr Geld und Zeit als man denken würde.
Interviewer: Danke für deine Zeit

Interview 2

Interviewer: Hallo, Vielen Dank dass du dir für das Interview Zeit genommen hast.
Head of HR: Gerne doch.
Interviewer: Ich würde dir gerne ein paar Fragen über die Mitarbeiterfluktuation in der Firma stellen
Head of HR: Ok
Interviewer: Was gibt es deiner Meinung nach für Gründe warum Mitarbeiter frühzeig ihren Job verlassen?
Head of HR: Schwierige Frage. Meistens passt der Job einfach nicht. Manchmal ist es aber auch weil Leute woanders hinziehen und natürlich bei einigen weil sie mehr Geld verdienen wollen und es nicht bekommen.
Interviewer: Gibt es noch andere Gründe?
Head of HR: Vielleicht weil die Mitarbeiter nicht die Möglichkeit haben sich zu entfalten oder weil sie nicht die selben Verantwortungen haben wie andere Mitarbeiter.
Interviewer: Kannst du mir Beispiele nennen was wir tun um die Mitarbeiterfluktuation zu reduzieren?
Head of HR: Wir versuchen ein gutes Arbeitsklima zu schaffen und wir bieten auch einige Zuckerl an wie Fitnessclub Mitgliedschaft, Firmenausflüge, Essensgutscheine oder Gehaltserhöhungen und Bonuse.
Interviewer: Wie teuer kommt es der Firma wenn Mitarbeiter trotzdem vorzeitig die Firma verlassen?
Head of HR: Die Leute die ohne Vorankündigung gehen kosten der Firma einiges. Wenn die Kündigungsfrist eingehalten wird, ist es nicht ganzs so schlimm.
Interviewer: Gibt es da konkrete Zahlen?
Head of HR: Im Schnitt kostet es der Firma ca. 5000 EUR wenn wir einen Mitarbeiter ersetzen müssen und es dauert ungefähr 3 Monate bevor der neue Mitarbeiter eingeschult ist. Das verursacht auch Kosten aber da habe ich keine genauen Zahlen dazu.
Interviewer: Und in der Personalabteilung selbst? Was entstehen da für Kosten?
Head of HR: Wir rechnen mit etwas über 1000 EUR pro Monat für Mitarbeitereinschulungen und Einstellungen für Ersatz von bestehenden Mitarbeitern

Interviewer: Danke für die Informationen. Abschliessend würde ich noch gerne wissen was du darüber denkst wenn wir diese Mitarbeiterfluktuationen reduzieren könnten.
Head of HR: Ich glaube es ist extrem wichtig dass wir diese Schwankungen reduzieren können, da sie der Firma extrem viel Geld kosten. Das Training und der Anstellungsprozess aber auch die Arbeitsleistung, die die Firma verliert. Durch die Mitarbeiter selbst und auch die Anschulung durch die Kollegen. Da könnten wir sehr sehr viel Geld sparen, wenn wir das auch nur geringfügig reduzieren könnten.
Interviewer: Vielen Dank, dass du dir die Zeit genommen hast.
Head of HR: Kein Problem

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Appendix III

Result of neural network evaluation data

res_a	pct_s	Wanted	Not Wanted	Reallife Match
0	91		x	x
0	95		x	x
0	92		x	x
1	75	x		x
0	74		x	x
1	74	x		x
1	81	x		x
0	80		x	
0	82		x	x
0	50		x	
1	90	x		x
0	72		x	x
1	97	x		x
1	77	x		x
1	81	x		
0	100		x	x
0	42		x	
1	73	x		x
0	62		x	
1	65	x		
0	92		x	x
1	76	x		
1	98	x		x
1	78	x		x
0	87		x	x
0	96		x	x
1	83	x		
1	97	x		x
0	75		x	
1	81	x		x
1	97	x		x
1	72	x		x
1	94	x		x
0	70		x	
1	72	x		x
0	82		x	x

0	64		x	
1	86	x		x
0	71		x	
0	80		x	x
1	65	x		
0	55		x	
0	80		x	x
1	71	x		x
1	81	x		
1	75	x		
0	73		x	x
1	100	x		x
1	84	x		
0	95		x	x
1	61	x		
0	73		x	x
0	54		x	
0	61		x	
1	51	x		
0	70		x	x
1	89	x		x
0	94		x	x
0	84		x	
1	90	x		x
1	94	x		x
1	80	x		
1	75	x		
1	80	x		x
0	88		x	
0	40		x	
1	70	x		x
1	85	x		x
1	73	x		x
1	46	x		
0	78		x	x
0	71		x	
1	88	x		x
1	73	x		x
1	84	x		x
0	44		x	
1	49	x		

1	87	x		
1	92	x		x
1	74	x		x
0	59		x	
0	76		x	x
0	95		x	x
1	66	x		
0	69		x	
0	73		x	x
0	83		x	
0	85		x	x
0	70		x	x
0	48		x	
1	81	x		x
1	91	x		x
1	85	x		x
1	99	x		x
0	89		x	x
0	95		x	x
0	73		x	x
0	99		x	x
1	82	x		x

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