

First Experiments on Interaction Quality Modelling for Human-Human Conversation

Anastasiia Spirina, Maxim Sidorov, Roman Sergienko and Alexander Schmitt
Institute of Communication Engineering, Ulm University, Albert-Einstein-Allee 43, Ulm, Germany

Keywords: Human-Human Interaction, Call Centres, Classification Algorithms, Performances.

Abstract: This work presents the first experimental results on Interaction Quality modelling for human-human conversation, as an adaptation of the Interaction Quality metric for human-computer spoken interaction. The prediction of an Interaction Quality score can be formulated as a classification problem. In this paper we describe the results of applying several classification algorithms such as: Kernel Naïve Bayes Classifier, k -Nearest Neighbours algorithm, Logistic Regression, and Support Vector Machines, to a data set. Moreover, we compare the results of modelling for two approaches for Interaction Quality labelling and consider the results depending on different emotion sets. The results of Interaction Quality modelling for human-human conversation may be used both for improving the service quality in call centres and for improving Spoken Dialogue Systems in terms of flexibility, user-friendliness and human-likeness.

1 INTRODUCTION

Speech is the main modality for human communication and the most natural user interface. Thereby Spoken Dialogue Systems (SDSs) are widespread in different areas. However, due to the fact that such systems are not as flexible as a human in communication and have a number of disadvantages, these systems need some indicator, which would reflect that something goes wrong during the interaction and the behaviour of the system should be changed. For a better understanding how such systems should respond to different situations, similar indicators may be introduced for human-human conversations (HHC).

This paper presents a first view on Interaction Quality (IQ) for HHC. Our idea of the IQ metric for HHC is based on the IQ metric for human-computer spoken interaction (HCSI), which was suggested in (Schmitt et al., 2011). In this work the authors introduced the term “IQ” instead of “User satisfaction” and explained the reasons for it.

Given the fact that HHC is more complex than HCSI, an adaptation of the initial rules for IQ labelling is required. We suggest two approaches for such an adaptation. The first one uses an absolute scale, like in the initial approach for IQ labelling for HCSI, whereas another approach consists of two

steps: firstly a scale of changes is used, which is then transformed into an absolute scale.

Another specific aspect of this work is the following: for understanding which emotions set is the best suitable for IQ modelling for HHC, we used the three different emotion sets. From each of them we generated two new sets:

- A set with the two classes (neutral emotions and others).
- A set with the three classes (negative, neutral, positive emotions).

For modelling IQ for HHC we decided to use the four classification algorithms implemented in *Rapidminer* and *WEKA* (Hall et al., 2009):

- Kernel Naïve Bayes classifier (NBK) (John et al., 1995).
- k -Nearest Neighbours algorithm (k NN) (Witten et al., 2011).
- L2 Regularised Logistic Regression (LR) (Ie Cessie et al., 1992).
- Support Vector Machines (Cristianini et al., 2000) trained by Sequential Minimal Optimisation (W-SMO) (Platt, 1998).

This paper is organized as follows. A brief description of related work (IQ for HCSI and some characteristics concerning HHC) is presented in Section 2. In turn, Section 3 gives information about the speech data used for IQ modeling for HHC and introduces two approaches for annotating IQ for

HHC. Then, Section 4 provides the achieved results of IQ modelling for HHC on different emotion sets and different approaches of IQ annotating. The obtained results are discussed in Section 5, which is followed in Section 6 by conclusions and concise description of future work.

2 RELATED WORK

The idea of applying IQ for HHC is based on the IQ paradigm, introduced in (Schmitt et al., 2011) for assessing the performance of an SDS during an ongoing interaction. The IQ metric allows to estimate, how the system is performing at any point during the interaction. The IQ metric is a 5-point scale: excellent, good, fair, poor, and bad. If the quality drops below a certain threshold, the dialogue strategies shall be changed in order to increase the quality again. The metric is based on features which are derived from the three dialogue system modules: Automatic Speech Recognition, Natural Language Understanding, and Dialogue Management. Moreover, these interaction parameters are designed on the three levels: the exchange level, comprising information about the current system-user-exchange, the dialogue level, consisting of information about the complete dialogue up to the current exchange, and the window level, containing information about the n last exchanges. The complete list of features can be found in (Schmitt et al., 2012). While the IQ metric has been proven to be beneficial in human-machine interaction scenarios, the approach may also help to assess the quality of human-human communication. This is for example of particular interest in call centres, where calls with the rather low quality of interaction have to be found for training and evaluation purposes.

There are different research works, which allow to assess different aspects of human speech in dialogues.

One of such a work is dedicated to the Customer Orientation Behaviours (COBs), which were suggested by the authors in (Rafaeli et al., 2008). The COBs include the following categories: anticipating customer requests, offering explanations / justifications, educating customers, providing emotional support, and offering personalized information. Within their research the authors have ascertained the positive relationship between the COB categories and the service quality, evaluated by customers. However, this approach allows to assess only an agent in a dialogue, but, nevertheless, the COBs are also an important aspect of interaction and can help to evaluate the quality of interaction

between an agent and a customer in general.

The authors in (Pallotta et al., 2011) described their approach to Call Center Analytics. It is based on Interaction Mining - a research field, which works with an extraction of useful information from conversations. The authors described the cooperativeness score as a measure, which was obtained from the argumentative labels, such as: accept explanation, suggest, propose, provide opinion, provide explanation or justification, request explanation or justification, question, raise issue, provide negative opinion, disagree, reject explanation or justification. Using the history of the calls the cooperativeness score can help to determine agents with constantly high cooperativeness score (positive cooperativeness) and customers with low cooperativeness score. Thus, it can help to improve the call centre performance by connecting more skilled agents with customers with uncooperative attitudes. The cooperativeness score gives a characteristic of agent's or customer's speech or their behaviour and may be used for the interaction quality evaluation.

Another important indicator for an estimation of the conversation quality, which is widely used in call centres, is customer satisfaction. A lot of works are dedicated to it.

In (Park et al., 2009) the authors suggested the approach, which allows to evaluate customer satisfaction automatically by analysing call transcripts consisting of various features, indicating linguistic, prosodic and behavioural aspects of speakers. Their experiments shown, that customer satisfaction may be evaluated both at the end and in the middle of calls.

The paper (Llimona et al., 2015), dedicating to customer satisfaction in a call centre, provides the research of an effect of gender and call duration on customer satisfaction in call centre big data. The authors found out the significant correlation between customer satisfaction (self-reported by a customer at the end of the call) and gender homophile between the customer and the employee.

The research works in the field of customer satisfaction may be applied for modelling IQ, despite of some differences between IQ and customer satisfaction. These differences between two metrics and their resemblance are described in (Schmitt and Ultes, 2015).

Moreover, there has been a lot of research dedicated to emotion recognition, verbal intelligent detection, agreement/disagreement detection and others. All these works are useful for different purposes and can be utilized for the evaluation of the conversation quality.

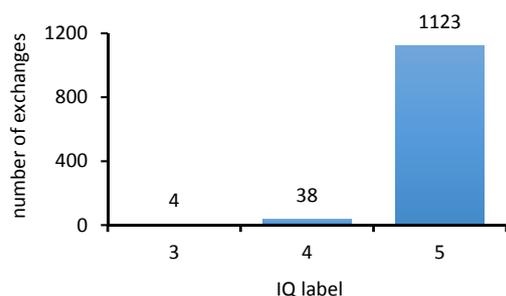


Figure 1: The IQ score distribution for the first approach of the annotation.

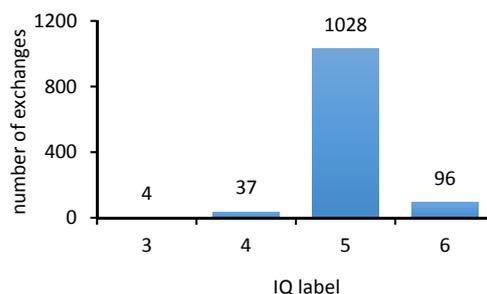


Figure 2: The IQ score distribution for the second approach of the annotation.

3 CORPUS DESCRIPTION

For our research we used the spoken corpus described by the authors in (Spirina et al., 2016). This corpus consists of 53 task-oriented dialogues between customers and employees with the total duration of approximately 87 minutes. It contains 1,165 agent-customer exchanges accompanied by the IQ labels. The corpus includes more than 1,200 features for each exchange: audio features (extracted by *OpenSMILE* (Eyben et al., 2013)) for an agent / customer / overlapping speech, paralinguistic information (such as emotions) and other dialogue features. All features in the corpus can be subdivided into the three groups: the exchange / window / dialogue parameter levels. These parameter levels are described in (Schmitt et al., 2012).

All exchanges from this corpus were annotated with an IQ score using two guidelines. As a basis for the IQ score annotating guidelines, we used the rater guideline described in (Schmitt et al., 2011).

For the first guideline we only adapted the guideline (Schmitt et al., 2011) to HHC. The IQ score distribution for the first approach of annotation is presented in Figure 1. We denote this IQ as IQ1.

In the second guideline we used a different approach: instead of an absolute scale a scale of changes has been applied. This scale shows how an IQ score has changed from the previous to the current exchange. Then we transformed this scale into an absolute one. Using an assumption, that all dialogues start with the IQ score “5”, and applying the received scale of changes, we became another IQ. Denote it as IQ2_abs. The distribution of the IQ2_abs scores is depicted in Figure 2.

The number of the observations for both IQ1 and IQ2_abs is highly unbalanced: the class with the IQ score “5” covers 96.39% and 88.24% of the observations correspondently.

The both guidelines are presented in Table 1.

4 EXPERIMENTAL SETUP AND RESULTS

The task for IQ modelling can be formulated as a classification problem, in our case with the three classes for IQ1 and the four classes for IQ2_abs. The total number of the formulated classification problems is eighteen. Each task is a combination of an IQ label (IQ1 or IQ2_abs) and a set of emotions (nine sets).

In this work we use nine sets of emotions: three main sets and two sets derived from each of them. The first set (em1) includes such emotion categories as angry, sad, neutral, and happy. The next set (em2) consists of such categories as: anxiety, anger, sadness, disgust, boredom, neutral, and happiness. The last set (em3) includes such categories as: fear, anger, sadness, disgust, neutral, surprise, and happiness. Subsequently, from each of the original sets, the two new sets were derived by subdividing the original set of emotions into neutral and other emotions (denote them as em{1,2,3}_2) and into negative, neutral and positive emotions (denote them as em{1,2,3}_3).

Before applying the classification algorithms each attribute has been normalized using the statistical normalization, which allows to convert the data into normal distribution with mean = 0 and variance = 1. In addition, all nominal attributes, such as emotions, gender and type of speaker (agent or customer) were transformed into numerical data.

4.1 Classification Algorithms

For solving these classification problems we used the algorithms implemented in *Rapidminer* and *WEKA*: NBK, kNN, LR, W-SMO.

Table 1: The guidelines for raters for IQ annotating in the absolute scale and the scale of changes (Spirina et al., 2016).

	The absolute scale	The scale of changes
1.	The rater should try to assess the interaction on the whole as objectively as possible, but pay more attention to the customer point of view in the interaction.	
2.	An exchange consists of the agent and the customer turns.	
3.	The IQ score is defined on a 5-point scale with “1=bad”, “2=poor”, “3=fair”, “4=good” and “5=excellent”.	The IQ score is defined on a 6-point scale with “-2”, “-1”, “0”, “1”, “2” and “abs 1”. First five points of the scale reflect changes in the IQ from previous exchange to current exchange. “abs 1” means “1=bad” in the absolute scale.
4.	The IQ is to be rated for each exchange in the dialogue. The history of the dialogue should be kept in mind when assigning the score. For example, a dialogue that has proceeded fairly poor for a long time, should require some time to recover.	
5.	A dialogue always starts with an IQ score of “5”.	A dialogue always starts with an IQ score of “0”.
6.	In general, the score from one exchange to the following exchange is increased or decreased by one point at the most.	
7.	Exceptions, where the score can be decreased by two points are e.g. hot anger or sudden frustration. The rater’s perception is decisive here.	
8.	Also, if the dialogue obviously collapses due to agent or customer behaviour, the score can be set to “1” immediately. An example therefore is a reasonable frustrated sudden hang-up.	Also, if the dialogue obviously collapses due to agent or customer behaviour, the score can be set to “abs 1” immediately. An example therefore is a reasonable frustrated sudden hang-up.
9.	Anger does not need to influence the score, but can. The rater should try to figure out whether anger was caused by the dialogue behaviour or not.	
10.	In the case a customer realizes that he should adapt his dialogue strategy to obtain the desired result or information and succeeded that way, the IQ score can be raised up to two points per turn. In other words, the customer realizes that he caused the poor IQ by himself.	
11.	If a dialogue consists of several independent queries, each query’s quality is to be rated independently. The former dialogue history should not be considered when a new query begins. However, the score provided for the first exchange should be equal to the last label of the previous query.	
12.	If a dialogue proceeds fairly poor for a long time, the rater should consider to increase the score more slowly if the dialogue starts to recover. Also, in general, he should observe the remaining dialogue more critical.	
13.	If a constantly low-quality dialogue finishes with a reasonable result, the IQ can be increased.	

For each algorithm we used the Grid parameter optimisation with 10-fold cross-validation, where F1-score (Goutte et al., 2005) was maximised. The settings for the classification algorithms are shown in Table 2.

4.2 Results

To assess the classification performance we accomplished 10-fold cross-validation to obtain statistically reliable results. We used such classification performance measures as accuracy, the unweighted average recall (UAR) as in (Ultes et al., 2012), F1-score, which were averaged over ten computations on different train-test splits.

The results of computations in terms of F1-score are presented in Table 3. The experimental results in terms of UAR can be found in Table 4, whereas Table 5 provides the accuracy for these experiments.

5 DISCUSSION

The one-way analysis of variance (one-way ANOVA) (Bailey, 2008), which helps to determine the statistically significant differences between the means of three or more groups, shows that for IQ1 through all classification performance measures there are no any statistically significant differences. For IQ2_abs through all tasks for all classification performance measures the one-way ANOVA determined, that the differences between means are statistically significant. To find out what algorithms gave statistically significant different results we used the Tukey’s honest significant difference (HSD) test (Kennedy et al., 1985). This test shows that almost in all the cases there are statistically significant differences between the results of NBK and other algorithms.

Table 2: The settings for the classification algorithms and parametric optimisation.

Parameter	Parameter's value
NBK	
<ul style="list-style-type: none"> ▪ laplace correction (helps to prevent high influence of zero probabilities) ▪ estimation mode ▪ minimum bandwidth ▪ number of kernels 	<ul style="list-style-type: none"> ▪ true ▪ greedy ▪ [0.01, 0.3], step 0.01 ▪ [1, 20], step 1
kNN	
<ul style="list-style-type: none"> ▪ <i>k</i> ▪ numerical measure ▪ kernel type ▪ kernel gamma ▪ kernel degree 	<ul style="list-style-type: none"> ▪ [1, 20], step 1 ▪ KernelEuclideanDistance ▪ anova ▪ [0.5, 5.0], step 0.5 ▪ [0.5, 5.0], step 0.5
LR	
<ul style="list-style-type: none"> ▪ <i>R</i> (sets set the ridge in the log-likelihood) 	<ul style="list-style-type: none"> ▪ [0.05, 0.95], step 0.05
W-SMO	
<ul style="list-style-type: none"> ▪ the complexity constant <i>C</i> ▪ the tolerance parameter <i>L</i> ▪ fit logistic models to SVM outputs ▪ kernel 	<ul style="list-style-type: none"> ▪ 1 ▪ 0.001 ▪ false ▪ polynomial

For the computations we used the one-way ANOVA and the Tukey's HSD test with the default settings, implemented in R programming language (R Development Core Team, 2008).

The accuracy baselines (classifier always predicts the majority class) for IQ1 and IQ2_abs are 0.964 and 0.882 correspondently. For F1-score the baselines are 0.327 and 0.234 respectively.

Given the fact that the data is highly unbalanced the results are not reasonable enough, although the obtained results outperform the baselines. Also the result can be not objective, since emotions and the IQ scores were annotated by only one expert rater.

The best results are highlighted in bold in Table 3, Table 4 and Table 5. It should be noted, that the algorithms, which show the best results in terms of one performance measure, can be not the best in terms of other performance measures. For example, for IQ1 in terms of F1-score the best results were obtained by W-SMO and NBK, in turn, in terms of accuracy the best results were achieved almost in all cases by LR. The same can be mentioned about the results for IQ2_abs. In terms of F1-score and UAR the best results were accomplished by kNN, which provides not such good results in terms of accuracy. Using optimisation with maximisation of other classification performance measures, instead of F1-score, the results may vary.

The use of the two scales shows that the initial scale, which was found suitable for HCSI, can lead to information loss in IQ modelling for HHC. It can be caused by a number of reasons, which can be a case for HHC, but not for HCSI.

Because of the extreme skew towards the IQ score "5" for both IQ1 and IQ2_abs, the reasonable question is why we should do any classification in this case. In general, the biggest part of the calls in call centres are neutral in terms of IQ. Such calls are not so interested for research in contrast to problematic calls, which can provide information for analysis and further improvement of the service quality. The corpus, which was used in this work, consists of 53 dialogues, which may be not enough.

Table 3: F1-score for the classification algorithms.

		IQ1				IQ2_abs			
		NBK	W-SMO	kNN	LR	NBK	W-SMO	kNN	LR
Emotions	em1	0.532	0.524	0.509	0.506	0.452	0.578	0.606	0.563
	em1_2	0.518	0.5	0.509	0.472	0.474	0.579	0.606	0.541
	em1_3	0.532	0.524	0.509	0.506	0.452	0.578	0.606	0.563
	em2	0.502	0.534	0.48	0.484	0.455	0.592	0.606	0.548
	em2_2	0.5	0.522	0.48	0.479	0.471	0.589	0.606	0.541
	em2_3	0.499	0.519	0.48	0.492	0.461	0.591	0.606	0.543
	em3	0.521	0.548	0.509	0.52	0.441	0.593	0.604	0.541
	em3_2	0.515	0.523	0.509	0.471	0.481	0.585	0.604	0.531
	em3_3	0.516	0.544	0.509	0.504	0.441	0.594	0.604	0.538

Table 4: UAR for the classification algorithms.

		IQ1				IQ2_abs			
		NBK	W-SMO	kNN	LR	NBK	W-SMO	kNN	LR
Emotions	em1	0.501	0.497	0.508	0.457	0.435	0.55	0.596	0.518
	em1_2	0.485	0.469	0.508	0.44	0.461	0.547	0.596	0.497
	em1_3	0.501	0.497	0.508	0.457	0.435	0.55	0.596	0.518
	em2	0.477	0.495	0.475	0.45	0.452	0.559	0.596	0.522
	em2_2	0.469	0.478	0.475	0.441	0.46	0.553	0.596	0.5
	em2_3	0.476	0.486	0.475	0.449	0.458	0.557	0.596	0.506
	em3	0.493	0.499	0.508	0.466	0.434	0.562	0.593	0.512
	em3_2	0.477	0.478	0.508	0.44	0.467	0.551	0.594	0.486
	em3_3	0.492	0.506	0.508	0.458	0.434	0.56	0.594	0.512

Table 5: Accuracy for the classification algorithms.

		IQ1				IQ2_abs			
		NBK	W-SMO	kNN	LR	NBK	W-SMO	kNN	LR
Emotions	em1	0.971	0.969	0.968	0.973	0.856	0.934	0.927	0.937
	em1_2	0.972	0.966	0.968	0.971	0.851	0.933	0.927	0.936
	em1_3	0.971	0.969	0.968	0.973	0.856	0.934	0.927	0.937
	em2	0.972	0.973	0.968	0.974	0.847	0.941	0.927	0.936
	em2_2	0.971	0.969	0.968	0.972	0.848	0.936	0.927	0.937
	em2_3	0.971	0.969	0.968	0.973	0.849	0.939	0.927	0.936
	em3	0.971	0.976	0.968	0.976	0.852	0.938	0.926	0.934
	em3_2	0.971	0.969	0.968	0.971	0.852	0.936	0.926	0.933
	em3_3	0.97	0.971	0.968	0.975	0.852	0.939	0.926	0.932

But the results, obtained on this data can be used for the further research.

6 CONCLUSION AND FUTURE WORK

In this paper we presented the first view of an adaptation of the IQ idea suggested by Schmitt et al. (Schmitt et al., 2011) to HHC. The further works in the field of IQ modelling for HHC may help to identify non-trivial patterns, which influence on the quality of conversation. These patterns, in turn, may be adapted and integrated into SDSs (in particular in a robot’s behavioural system), what possibly will be utilized for improving the quality of spoken interaction between users and SDSs.

As a future direction we plan to use other classification algorithms and ensembles of

algorithms. Caused by high dimensionality of the feature space the application of dimensionality reduction methods are required both for decreasing the computational complexity and for increasing classification performance measures. Furthermore we plan to increase the number of expert raters to obtain more objective data. Finally, due to the problems of an interpretation of different IQ scores for HHC (especially for IQ2_abs), we plan to suggest an alternative scale for measuring IQ for HHC with less subjectivity and an easily interpretable scale.

ACKNOWLEDGEMENTS

The work presented in this paper was supported by the DAAD (German Academic Exchange Service).

REFERENCES

- Bailey, R. A., 2008. *Design of comparative experiments*, Cambridge University Press.
- le Cessie, S., van Houwelingen, J. C., 1992. Ridge Estimators in Logistic Regression. *Applied Statistics*, Vol. 41, No. 1, pp. 191-201.
- Cristianini, N., Shawe-Taylor, J., 2000. *An introduction to Support Vector Machines and Other Kernel-based Learning Methods*, Cambridge University Press.
- Eyben, F., Weninger, F., Gross, F., Schuller, B., 2013. Recent Developments in openSMILE, the Munich Open-Source Multimedia Feature Extractor. In *Proceedings of ACM Multimedia (MM)*, pp. 835-838.
- Goutte, C., Gaussier, E., 2005. A probabilistic interpretation of precision, recall and f-score, with implication for evaluation. *Advances in information retrieval*. Springer.
- Hall, M., Frank, E., Holmes, G., Pfahringer, B., Reutemann, P., Witten, I. H., 2009. The WEKA Data Mining Software: An Update. *SIGKDD Explorations*, Vol. 11, No. 1.
- John, G.H., Langley, P., 1995. Estimating Continuous Distributions in Bayesian Classifiers. In *Eleventh Conference on Uncertainty in Artificial Intelligence, San Mateo*, pp. 338-345.
- Kennedy, J. J., Bush, A. J., 1985. *An introduction to the design and analysis of experiments in behavioral research*, University Press of America.
- Llimona, Q., Luque, J., Anguera, X., Hidalgo, Z., Park, S., Oliver, N., 2015. Effect of gender and call duration on customer satisfaction in call center big data. In *Proceedings of Interspeech*, pp. 18525-1829.
- Pallotta, V., Delmonte, R., Vrieling, L., Walker, D., 2011. Interaction Mining: the new frontier of Call Center Analytics. In *CEUR Workshop Proceedings*.
- Park, Y., Gates, S. C., 2009. Towards real-time measurement of customer satisfaction using automatically generated call transcripts. In *Proceedings of the 18th ACM conference on Information and knowledge management, New York*, pp. 1387-1396.
- Platt, J., 1998. Sequential Minimal Optimisation: A Fast Algorithm for Training Support Vector Machines. *TechReport MSR-TR-98-14, Microsoft Research*.
- Rafaeli, A., Ziklik, L., Doucet, L., 2008. The Impact of Call Center Employees' Customer Orientation Behaviors on Service Quality. *Journal of Service Research*, Vol. 10, No. 3, pp. 239-255.
- R Core Team, 2015. *R: A language and environment for statistical computing*, R Foundation for Statistical Computing. Vienna, Austria. <http://www.r-project.org/>.
- Schmitt, A., Schatz, B., Minker, W., 2011. Modeling and predicting quality in spoken human-computer interaction. In *Proceedings of the SIGDIAL 2011 Conference. Association for Computational Linguistics*, pp. 173-184.
- Schmitt, A., Ultes, S., Minker, W., 2012. A Parameterized and Annotated Corpus of the CMU Let's Go Bus Information System. In *International Conference on Language Resources and Evaluation (LREC)*.
- Schmitt, A., Ultes, S., 2015. Interaction Quality: Assessing the quality of ongoing spoken dialog interaction by experts – And how it relates to user satisfaction. *Speech Communication*, Vol. 74, pp. 12 – 36.
- Spirina, A. V., Sidorov M. Yu., Sergienko, R. B., Semenkina E. S., Minker, W., 2016. Human-Human Task-Oriented Conversations Corpus for Interaction Quality Modelling. *Vestnik SibSAU*, Vol. 17, No. 1.
- Ultes, S., ElChabb, R., Minker, W., 2012. Application and Evaluation of a Conditioned Hidden Markov Model for Estimating Interaction Quality of Spoken Dialogue Systems. In *Proceedings of the 4th International Workshop On Spoken Dialogue Systems (IWSDS)*, pp. 141-150.
- Witten, I. H., Frank, E., Hall, M. A., 2011. *Data mining: practical machine learning tools and techniques*, Morgan Kaufmann. USA, 3rd edition.