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TABLE OF CONTENTS

Committees 3

Table of Contents 7

Proto-cluster: A Parallel Computer Architecture Based on Prototyping Boards 15
N. Ádám, M. Hulič, E. Chovancová, E. Pietriková, T. Gergely

IT Academy project: Model of class focused on informatics 21
N. Adamko, G. Andrejková, J. Guniš, R. Hrušecký, A. Hrušecká, Ľ. Jašková, J. Sekerák, M. Spišáková, Ľ. Šnajder, M. Varga

Innovation of University Subjects in Data Science Area within IT Academy Project 31
Ľ. Antoni, E. Bruoth, J. Guniš, P. Gurský, S. Krajči, O. Krídlo, R. Navrátil, Ľ. Šnajder, G. Andrejková, D. Šveda

New trends in mobile technologies education in Slovakia: an empirical study 37
F. Babič, V. Gašpar, P. Šatala

Use of Computer Technologies in Development of Mathematical Thinking 43
K. Bachratá, H. Bachratý, K. Kovalčíková

Experiences of Using Real-Time Classroom Response Systems 51
V. H. Bakonyi, Z. Illés

Simulation Tool for Tuning of the Speed Servo Drive 57
I. Bélai, V. Goga

Analysis of the Influence of Electronic Word-of-Mouth on University Choice by Slovakian Grammar School Students 63
M. Beno

Disturbance Analysis Virtual Laboratory for PID Controllers with Higher Derivative Degrees 69
P. Bisták

Fuzzy Rule Miner: A Software Library Used in Project Based Teaching of Topics Related to Knowledge Discovery in Databases 75
J. Bohacik, M. Zabovsky

Audience Response Systems: The power of academic personal presentation 81
P. Čech, E. Pietriková, A. Baláž

Development, tendency, testing and success of marketing communications 87
P. Červenka, J. Naščáková, L. Bednárová, N. Daneshjo, E. Dudáš-Pajerská

The new directions of research in the application of effective marketing communication 93
P. Červenka, J. Naščáková, L. Bednárová, N. Daneshjo, E. Dudáš-Pajerská

Automated Evaluation of a Network Device Configuration 99
Z. Csengődy, D. Macko, K. Jelemenská

Enhanced Interoperability with New Collaborative and Streaming Functions Implemented in Slovak National Telepresence Infrastructure (NTI) 105
D. Cymbalak, F. Jakab, R.Vápeník, M. Michalko, J. Turňa, Ľ. Bilský, J. Kováčová

Development of Human Resources - Learning in Clouds 111
A. Czaja, A. Grabowska

Online Questionnaires – Collection and Analysis of Student's Views on Operating Systems Course 117
A. Deák, Z. Bilanová, M. Vrábel, J. Genči

Methods of traffic load balancing in high-speed optical systems 123
I. Dolnák, J. Litvik

Using Mathematical Software with Support for Students with Visual Impairments 127
E. Draženská, D. Šimšík, A. Galajdová

Improved process of running tasks in the high performance computing system 133
A. Dudáš, P. Voštinár, J. Škrinárová, J. Siláči

Issues with the detection of plagiarism in programming courses on a larger scale 141
M. Ďuračík, E. Kršák, P. Hrkút

Survey on communication in Internet of Things environment 149
J. Erdelyi, P. Čičák

Gloffer – Product catalogs building and products comparing in product catalogs, taking into account the multi-currency and multi-linguality of indexed content 157
R. Fasuga, K, Seifriedová, E. Kubanda, V. Pilík, J. Rýdel, M. Kuchařík

Teaching module of mathematical methods in Reliability Engineering 163
A. Forgac, P. Rusnak

Issues of adaptive interfaces and their use in educational systems 173
D. Gabriska, M. Ölvecký

Improving the user experience of electronic university enrollment 179
L. Galko, J, Porubän, J. Senko

The Past Seven Years of Development of the Framework for Teaching Programming and the Students' Results 185
R. Horváth

Serious game in science education: How we can develop mathematical education 191
M. Hosťovecký, I. Šalgovič, R. Virágh

Step by Step to the World of Science and Technology 197
J. Hrbacek, L. Stuchlikova

An Implementation of Efficient Hierarchical Access Control Method for VR/AR Platform 205
T.-C. Hsiao, K.-Y. Tai, Y.-M. Huang, Y.-F. Chung, Y.-C. Wu, T. Kurniati, T.-S. Chen

Gesture control for cognitive training based on VR Technologies 209
M. Hudák, B. Sobota, Š. Korečko

Case Study of Ransomware Malware Hiding Using Obfuscation Methods 215
J. Hurtuk, M. Chovanec, M. Kičina, R. Billík,

Scaffolding Mathematical Prerequisites to STEM Students by Solving Non-Traditional Problems 221
J. Hvorecký

FRIskill Knowledge Base Management System 229
O. Chovancova, T. Postek, J. Bohacik

The basis for choosing MicroLearning within the terms of e-Learning in the context of student preferences 237
T. Javorcik, R. Polasek

Continual Improvement Process in Scientific Publishing 245
G. Juhás, L. Molnár, A. Juhásová, M. Ondrišová, M. Mladoniczky, J. Mažári

The Learning Styles of the Generation Group Z and Their Influence on Learning Results in the Learning Process 251
R. Jurenka, A. Stareček, N. Vraňaková, D. Cagáňová

The eSEC Portal as a Tool for the Concept of Corporate Social Responsibility 261
K. Kampova, K. Makka, Z. Zvakova, W. Pellowksi

EEG Based Voice Activity Detection 267
M. Koctúrová, J. Juhár

ChipDE – A Development Environment for SystemVerilog-based Digital IC Design 273
L. Kohútka, V. Stopjaková

A Country Benefits Related to Education Sector using the Data for Input-Output Analysis 279
G. Koľveková, D. Palaščáková

Active learning in data science education 285
V. Konkoľová, J. Paralič

Testing of the current open-source EIGRP implementations 291
M. Kontšek, P. Segeč

A survey of the EIGRP standard and following open-source implementations 297
M. Kontšek, P. Segeč, M. Moravčík, J. Uramová

Application of Modern Technologies in the Creation of an Interactive Education Portal 305
J. Kostolny, J. Bohacik, T. Hianik, P. Vestenicky, T. Pecenkar, M. Lapin

Interactive tools of computer support in the learning of construction processes technology – case study 311
M. Kozlovska, J. Cabala, M. Spisakova

Approach for Hierarchical Global All-In Classification with application of Convolutional Neural Networks 317
M. Krendzelak, F. Jakab

Personal coaching of students in real-life programming theses 323
T. Lenger, E. Pietriková, N. Ádám

High-capacity wavelength division multiplexing optical transmission systems 329
J. Litvik, I. Dolnák, M. Dado

Implementation of SCRUM methodology in programming courses 333
M. Madeja, M. Biňas

Biofeedback as part of pedagogical self-reflection 341
M. Malcik, M. Miklosikova

Improved smart gateway in IoT 349
L. Mastilak, M. Galinski, I. Kotuliak, M. Ries

Online Tool for Creating Simple Models of Mechanical Systems 355
J. Matišák, K. Žáková

Spreadnig High Performance Computing Skills with E-Learning Support 361
M. Melicherčík, V. Siládi, M. Svítek, L. Huraj

Applications of knowledge technology in construction industry 367
P. Mesároš, T. Mandičák, M. Behún, J. Smetanková

An overview of Building Information Modeling Libraries 373
P. Mesároš, J.Smetanková, A. Behúnová, J. Talian

Comparison of BIM education process in construction management field at Technical University of Košice and University of Zagreb 379
P. Mesároš, T. Mandičák, M. Vukomanović, S. Kolarić

Draft of Firefighter Education Process through Distance Learning 385
B. Mikula, A. Tobisová, D. Blaško, I. Vajdová, E. Jenčová, L. Melníková, S. Szabo jr., S. Szabo, V. Němec

Scaling and structuring of digital literacy **389**
L. Molnár, G. Juhás, M. Ondrišová, A. Juhásová, J. Mažári, M. Mladoniczky

Overview of Cloud Computing standards **395**
M. Moravcik, P. Segec, M. Kontsek

Relationships between game attributes and cognitive abilities **403**
M. Ölvecký, D. Gabriska

Analysis of turn-taking in the Slovak interview corpus **411**
S. Ondáš, J. Juhár

Overview of IP Fast Reroute solutions **417**
J. Papán, P. Segeč, M. Moravčík, M. Konštek, Ľ. Mikuš, J. Uramová

Convergence of routing protocols in real and simulated environments **425**
R. Petija, M. Michalko, F. Jakab, P. Feciľak

Engaging Students at a Distance: Advantages and Pitfalls of Video-conference Use in Teaching **431**
K. Pisutova, R.C. Rogers, J. Mercer

Challenging the Education in the Open Laboratory **439**
J. Porubän

Interactivity in learning materials for the teaching **445**
I. Pšenáková, T. Szabó

Network Tester: A Generation and Evaluation of Diagnostic Communication in IP Networks **451**
J. Pullmann, D. Macko

Ball Levitation Using EEG Headset via Bluetooth **457**
M. Rábek, K. Žáková

Key Indicators for Student Performance at the E-Learning Platform: An SNA Approach **463**
S. Rakic, S. Softic, M. Vilkas, B. Lalic, U. Marjanovic

Estimation of the Wall Thickness and Relative Permittivity by Radar System **469**
M. Repko, J. Gamec, P. Kurdel, M. Gamcová

Software Tool for Manipulation with Decision Diagrams Used in Reliability Analysis **475**
P. Rusnak, L. Cajka, M. Kvassay

Tool for supporting Education process in Information technology **483**
P. Sedlacek, M. Vaclavkova

Entrepreneurial University as Innovation Hub in Transitional Economy: New Digital Platform for SME Globalization **489**
Y. V. Seniuk

Possibilities of Utilization Chaos for the Cognitive Tests Using Virtual Reality Technologies **499**
B. Sobota, M. Guzan

Digital Calibration of Low-Voltage and Low-Power Analog ICs **505**
M. Šovčík, V. Stopjaková, D. Arbet, M. Kováč

The Level of Cognitive Abilities of Generational Group Y and Educational Process **511**
A. Stareček, M. Bednáriková, K. Koltnerová, N. Vraňaková, Z. G. Babeľová, D. Cagaňová, A. Chlpeková

Impact of Motivational and Training Activities on Awareness of Building Information Modeling **519**
Z. Struková, R. Bašková, K. Krajníková

Support of Student Motivation as Key Condition for Successful University Graduates in Engineering Education **527**
L. Stuchlíková

Design of a Training System for Mobile E-learning with the Application of E-technology **533**
P. Šuľaj, R. Haluška, P. Galajda, Ľ. Ovseník, S. Marchevský

A Mobile Game to Teach AVL Trees **541**
D. Šuníková, Z. Kubincová, M. Byrtus

UWB-PerLoc-MAT: MATLAB App for Person Localization by UWB Sensor **545**
M. Švecová, D. Kocur, M. Švingál

Cloud Computing and Numerical Mathematics **551**
P. Szabó, V. Moucha, M. Ferencová

Quadcopter control **557**
P. Ťapák

IoT plant watering **563**
P. Ťapák, M. Csiba

Usability of an Open Space Class Location and Schedule Application **569**
T. Tarkanič, M. Madeja, L. Galko, J. Porubän

The Other Kind of Machine Learning: Modeling Worker State for Optimal Training of Novices in Complex Industrial Processes **577**
C. Thomay, B. Gollan, M. Haslgrübler, A. Ferscha, J. Heftberger

Application of Laser Scanning Technology for Information Modeling of Existing Buildings **583**
M. Tkáč, P. Mesároš, T. Mandičák

From App Inventor to Java: A Strategy for Mediating the Transition **591**
T. Tóth, V. Michaličková

Virtual Reality Applications in STEM Education 597
P. Truchly, M. Medvecký, P. Podhradský, M. Vančo

Infrastructure for generating new IDS dataset 603
J. Uramová, P. Segeč, M. Moravčík, J. Papán, M. Kontšek, J. Hrabovský

Creation of a Software Tool in Project Based Teaching for the Recruitment of Employees into Security Companies 611
M. Vaclavkova, J. Bohacik

Safety as necessary aspect of automated systems..... 617
M. Vagaš, D. Šimšík, A. Galajdová, D. Onofrejová

Exploration of the LoRa Technology Utilization Possibilities in Healthcare IoT Devices..... 623
A. Valach, D. Macko

Concept of Intelligent Space in Education of IoT Applications in Robotics..... 629
J. Vaščák, E. Kajáti, I. Zolotová

STEM Experiences in Primary and Lower Secondary Schools 635
P. Voštinár, N. Klimová

Generational Groups of Employees and the Importance of their Education in the Context of the Age Management Concept..... 641
N. Vraňaková, A. Stareček, K. Koltnerová, A. Chlpeková, D. Cagáňová

Author Index 647

Analysis of turn-taking in the Slovak interview corpus

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***Abstract*—Proposed paper deals with the turn-taking mechanisms in the dyadic human-human interactions in Slovak language. Described research aims to bring an initial analysis of the turn-taking behavior. We decided mainly to focus on overlapping speech segments. Human-human dyadic interactions were analyzed on the small corpus of interactions, to identify intention of taking a floor by the listener before speaker's turn end.**

I. INTRODUCTION

Nowadays we can observe increasing number of dialogue-based applications due to the new intelligent devices and solutions. Virtual assistants start to be a part of our daily life. Amazon add their Alexa to the LG fridge or microwave oven. Spoken dialogue interfaces start to be a standard interface for in-car infotainment systems (Android Auto, Apple CarPlay, etc.). We must not forget on category of social and family robots and on humanoid robots. Their embodied character favorizes the spoken interaction with people.

All these facts underlie an importance of human-machine spoken dialog research. Moreover, there are almost no works, which focuses on Slovak dialogues. This motivate us to analyze human-human dialog interactions to be able to enhance human-machine dialog. Our motivation was supported by the fact that there exist corpora with dialogue interactions in Slovak in our laboratory (Laboratory of speech and mobile technologies), which are used for training of automatic speech recognition systems.

Mentioned corpus contains audio and video recordings of dyadic interactions, which are transcribed by human annotators. Expect the textual information that relates to the content, transcriptions contain information about speakers and about each turn proposed during interaction. Moreover, overlapping segments are also marked.

As Akker and Bruijnes concludes in [32] "*One of the basic conversational skills is to know when to take the turn and what it means when someone starts talking out of turn, or remains silent when he is expected to give an answer.*" This statement defines turn-taking research domain very well.

The proposed paper focuses on analysis of turn-taking issues in human-human dyadic dialog interactions in Slovak language. The gap between fluentness of human-human interactions in comparison with human-machine dialogue interactions is the motivation behind this work. We need to understand how turn-taking is performed.

The very small or no delay characterize human-machine turn changes. Often, we observe smaller or bigger overlaps during the speakers change. We decided to focus on overlaps and interruptions of the speaker by the listener, to uncover when and why such turn-taking approach is usually used by interlocutors. The proposed work was invoked by the work described in [33] and [16], where we studied an anticipation phenomenon.

In [33] we proposed an assumption, that one of the reasons, why overlaps or interruptions occurs is, that a listener is able to anticipate few last words in the just unfolding speaker turn. To support this assumption, analysis of real human-human interactions needs to be performed.

Three recordings of discussions, with the duration almost two hours, were analyzed, where frequency of overlaps and interruptions were computed and reasons, which led the listener to interrupt the speaker were manually extracted. Then, observed results were analyzed and discussed.

The paper is organized as follows. The section II. describes the anticipation phenomenon.

II. ANTICIPATION

The phenomenon of anticipation was studied in range of the national project "*Anticipatory Phonetic Strategies for Simultaneous and Consecutive Interpretation*" (APVV-15-0307), solved in partner's laboratory LICOLAB (Language, Information and Communication Laboratory). It deals with prosody aspects that helps to identify an anticipation core - the point, where an interpreter has enough information to anticipate (predict) remaining words of just interpreted utterance.

Anticipating in simultaneous interpreting means that interpreters say a word or a group of words before the speaker actually says them [1]. In [18] anticipation is defined as strategy, by which the interpreter attempts to guess a sentence constituent, before it has been uttered in the original. It means that interpreters, familiar with the domain and content, can interpret beforehand thank to the anticipation. Anticipation is a key competence that interpreters need to learn before they can become professionals [1], [17].

During a presentation day of the above-mentioned project a real demonstration of this phenomenon was performed by a group of interpreters. Participants can also performed exercises, which test their ability to anticipate words from just unfolding sentence. It was interesting to observe that also untrained listeners were able to predict the end of the utterance very effective in case of so called "predictable sentence". This experience leads us to think about anticipation in case of human-human and human-robot dialogue interactions.

In the area of human-machine and human-human dialogue interactions, it seems that anticipation play a very important role, because it influences the speed of response in conversation (see [2]) and it is a critical ability to enable "rapid" turn-taking. Anticipation allow the speaker to interpret partial utterances. Sagae et al highlights the importance of anticipation, when they conclude in [12] „*To achieve more flexible turn-taking with human users, for whom turn-taking and feedback at the sub-utterance level is natural, the system needs the ability to start interpretation of user utterances before they are completed.*" and „*it also includes an utterance completion capability, where a virtual human can make a strategic decision to display its understanding of an unfinished user utterance by completing the utterances itself*".

As is clear from several studies, where EEG signals were measured (see [2], [3]), people are able to anticipate turn ends during the dialogue interaction. There are also several other works, which confirm the human ability to anticipate, (see also [4], [6]).

According findings made by Magyari et al. in [2], it seems that in case of so called „predictable" sentences, people can predict around five last words of particular turn. As authors concludes, anticipation enable rapid turn-taking, where it reduces the gap between turns in dialog.

As Magyari et al. in [2] describes, anticipation of last words of the speaker turn, provides a special time (around 600ms in case of "unpredictable turns" and around 1250ms in case of "predictable" turns) to the listener and his speech production system to start formulation of his own turn. Here, the incremental approach to speech production is also important, because it enables early to start speaking an actual most probable utterance and then modify it according new/final hypothesis. This is exactly the same what interpreters do when simultaneously interpret beforehand.

In case of application anticipation in human-machine dialogue interactions, there exists only few works that deals with this phenomenon. We can mention the work of Dominey et al., described in [5], which focuses on next turn anticipation, based on dialogue history, but in this case the anticipation is not focused inside the turn. Sagae et al. focus their work on interpretation of partial utterances, where they are using words prediction – anticipation. They realize an idea of the incremental user utterance processing, which enables to increase speed of turn-taking (switching the speaker).

To be able to add anticipation capability to machine interlocutor of the human-machine dialogue, anticipation phenomenon need to be deeply analysed in human-human interactions. Moreover, we assume that, there can exist differences for different cultures and languages.

A. Anticipation in human-human interactions

Anticipation is routinely used during human-human conversations. Expect the measured results, which indicates this activity (described e.g. in [2]), there can be identified also other qualitative indicators. We consider three of them as a specially important – *unfinished utterances* (turns), *interruptions* and *overlaps*.

Unfinished turns sometimes occurs in natural human-human conversations. We believe that one of the reasons, which lead the speaker to let his turn unfinished is, that he takes into consideration that the listener can complete a given sentence without he need to finish it. In other words, speaker anticipate that listener is able to anticipate the end of speaker's turn (see example in Fig. 1.).

S1: *How did you find out?*
S2: *I walked down the hallway, the door was open and so I... (looked in)*
S1: *Uhm*

Figure 4. An example of unfinished phrase

However, there can be also other reasons, which are considered by the speaker. Irrelevance of the remaining part of the turn can be one of them.

Overlaps and interruptions need to be also considered as the possible indicators of anticipation.

Interruptions differs from overlaps in the timing. Listener usually use a small pause in the speaker turn to interrupt the speaker and to take a floor without causing an overlap. There can be also several reasons of this behavior. If we consider anticipatory strategies usually used in simultaneous interpretation, pauses in speaker utterances are often the place, where the interpreter starts to interpret beforehand. It indicates, that somewhere there, the place of the anticipation core ([16]) or "moment of the maximum understanding" ([12]) is located.

The very interesting category of events are overlaps or overlapping speech, when both interlocutors are speaking simultaneously. We believe that one of the reasons for such interaction behavior is that listener is able to anticipate, but the relation between overlapping speech and anticipation phenomenon need to be more researched.

To take the floor can looks like a general reason for jumping into speaker turn, but the situation is more complicated. Simultaneous speech can occur also in case of providing feedback to the speaker by the listener, or to provide additional information. Moreover the attempt to take the floor can have several reasons, where, one of them is that the "maximum understanding moment" were reached and the listener is able to anticipate remaining part of the sentence.

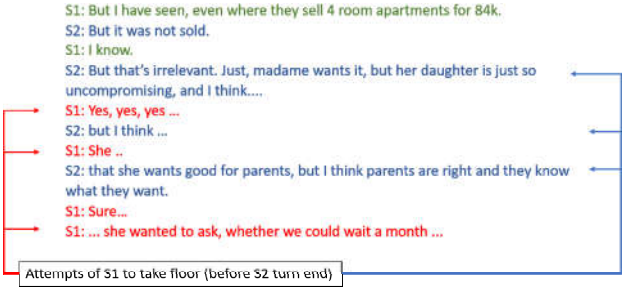

Figure 5. An example of taking a floor before turn end

In our study we have started to analyze overlaps and interruptions, their occurrences and we have tried to identify all reasons, which can be behind described behavior (interruption of the speaker). As was mentioned, we believe that turn-taking is a language- and culture-dependent, therefore we focus on Slovak interactions, which did not analyze from this point of view before.

Expect of comprehension indicators in EEG signal, a mutual understanding or comprehension on the listener side can be observed from so called backchannel signals, which are usually produced by human listeners. **Backchannel signals** was defined by Yngve [7] as non-intrusive acoustic and visual signals provided during the

speaker's turn. Allwood et al. and Poggi in [8, 9], uncover meaning of acoustic and visual backchannels that they provide information about the basic communicative functions, as perception, attention, interest, understanding, attitude (e.g., belief, liking) and acceptance towards what the speaker is saying. Bevacqua et al. in [10] described a work focused on extending an Embodied Conversational Agent (ECA) with listener capabilities. They defined some associations between the listener's communicative functions and a set of visual (and vocal) signals. They performed an experiment with the 3D Embodied Agent Greta [11], which confirm defined associations. Among others, in this experiment has been shown, that there exist the association between *understanding* and following multimodal backchannel signals: *raise eyebrows+"ooh"*, *head nod+"ooh"*, *head nod+"really"*, *head nod+"yeah"* and *head nod*.

Despite the similarity of an understanding/partial understanding and a point, when interlocutor is able to anticipate words up to turn end, it is very important to distinguish them. Unfortunately, it can be difficult to distinguish these two phenomena. We suppose that a complete comprehension done be anticipation lead to taking a floor, while a partial understanding is signalized only be providing a backchannel, without taking a floor. This assumption needs to be more researched.

Moreover, we believe, that turn-taking behavior depends on many other factors: mood, relationship of interlocutors, dialogue topic, emotions, type of dialogue (task-oriented, interview, free conversation, small talk, cooperative work, etc.). Especially emotion can influence a turn-taking significantly. In the future, automatic sentiment analysis, described in [36], can be involved to uncover this relation.

B. *Anticipation in the Spoken Dialogue Systems*

One of the widely used solution, which enables machines to react on earlier comprehension (before machine turn end) is barging in mechanisms (barge-in functionality). It enables human dialogue participant to interrupt the machine's speech before machine turn end. Barge-in functionality is explicitly defined as a standard tool in VoiceXML language (see VoiceXML spec.).

However, barging-in can be seen as a solution, which successfully cover early comprehension capability of humans, let us thing a step further. Are speakers changing utterance production patterns in case of „predictable" utterances? Our observations support this assumption. We assume that there exists a point in which a common understanding is established during speaking and listening, and where a speaker sometimes stops its turn and let it unfinished.

On the opposite side, we need to thing about machine anticipation, or ability to find an enough reliable hypothesis of unfold utterance just uttered by human interlocutor.

Machines that can communicate with user through spoken language implements a human machine communication chain (see Fig. 3), which consists of few basic components.

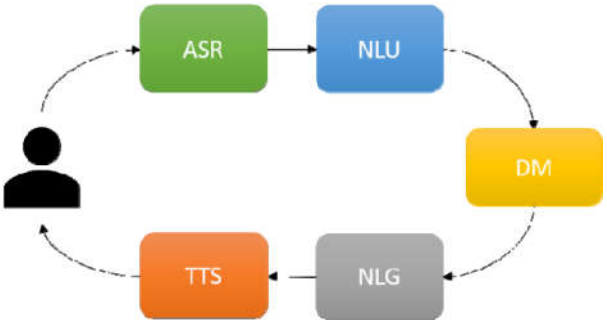

Figure 6. Human-machine speech communication chain

We can observe or describe a general anticipation on several levels related to components. According related component we have defined several types of anticipation.

In case of Automatic Speech Recognition (ASR) module, acoustic and language model defines the recognition network, which contains possible ways of interpreting input speech. Usually this network is created before the operation of the system. The recognition network enables to produce several hypotheses of the recognition result, but they occur not earlier than input speech. But, we assume, that such network could be used also to predict next words according previously recognized words. The simplest way how to anticipate words in sentence is to involve the language model, which models probabilities of word n-grams.

There is another interesting issue, whether the attention should be focused on exact word sequence anticipation or meaning anticipation. This issue relates to the next module from the human-machine speech communication chain - Natural Language Understanding (NLU) module. It's clear that if we want to speed up the turn taking process, meaning extraction (understanding) process must begin before the speaker terminates his turn. It means, that we need to work with semantic hypothesis, which is based on recognition hypothesis. This means, that the semantic module need to be able to process unfinished, partial utterances. Sagae et al. in [12] describes an approach to ability to find an enough reliable hypothesis of unfold utterance just uttered by human interlocutor.

But human brain goes a step further, because, it seems that semantic hypothesis is derived from feedforward utterance hypothesis, which is anticipated by human listener. So, we propose, that it could be interesting to research incremental semantic interpretation, which is based on anticipated utterances and to observe the accuracy and the possibility of positive influence the speed of turn-taking.

Moreover, speech act recognition should also be placed in parallel to speech recognition and natural language processing. It can be done by considering recognition hypothesis based on anticipated words and semantics. In case of dialogue management, the situation is much more simpler, due to the power of dialogue history, which can be successfully used to predict interlocutor next speech act (see [5]). All mentioned facts supports idea of so called „incremental Spoken Dialogue Systems" (see e.g. [13] or [14]).

Described anticipation potential of the human-machine speech communication chain modules shows that machines can anticipate, because particular modules use

resources with this ability (e.g. recognition network, language models, dialogue history).

While, the anticipation skill can be consider as non-important for simple task-oriented systems, it can bring more human-like interactions and advantages in case of systems for multi-party conversations, for human-machine collaboration scenarios or for crisis scenarios, where can be useful or necessary for the machine to be able to rudely interrupt a human speaker(s), to be able to take a floor and to propose ideas or solutions.

III. CORPUS

Corpus of the investigative interviews of the TV program "*Na rovinu*" and epizodes of TV discussions "*Pod lampou*" were selected for the analysis of turn-taking mechanisms.

The overall length of the analyzed corpus was 99 minutes and 36 seconds. There were 5 speakers (4 male, 1 female), two of them play a role of the moderator (male).

Recordings were transcribed in two-level procedure. The first transcriptions were generated by our automatic transcription system (see [X]). Then, transcriptions were corrected and a set of special markups were included by human experts. Final transcriptions have a form of .trs files, which are generated by Transcriber tool. An example of the transcribed recording can be seen on Fig. 4.

IV. RESULTS

To analyse turn-taking aspects, all transcriptions were processed, to evaluate following measurable turn-taking characteristics:

- *Total number of turns in dialog*
- *Number of 1. speaker turns*
- *Number of 2. speaker turns*
- *Number of overlaps and interruptions*
- *Number of interruptions made by first speaker* (moderator)
- *Number of interruptions made by second speaker*
- *Number of mixed overlaps*, where both interlocutors started to speak simultaneously
- *Overlaps ratio* – the ratio between number of overlaps (incl. interruptions) and total number of turns.
- *First speaker overlap ratio* – express ratio between overlaps made by the first speaker and turns of the second speaker. Express how many turns of second speaker were interrupted by the first speaker
- *Second speaker overlap ratio* – express ratio between overlaps made by the second speaker and turns of the first speaker.

The next part of the analysis was focused on the reasons, which lead the listener to interrupt the speaker. We identify following 15 categories of reasons, which were further analysed:

- Stop the speaker
- Confirmation of information
- Clarification
- Completing the information
- Anticipation
- Support continuation of speaker turn (backchannel signal)
- Express noninterest/irrelevance – topic change
- Try to take the floor
- Unclear
- Try to take floor (back) by force
- To provide additional information/statement (to

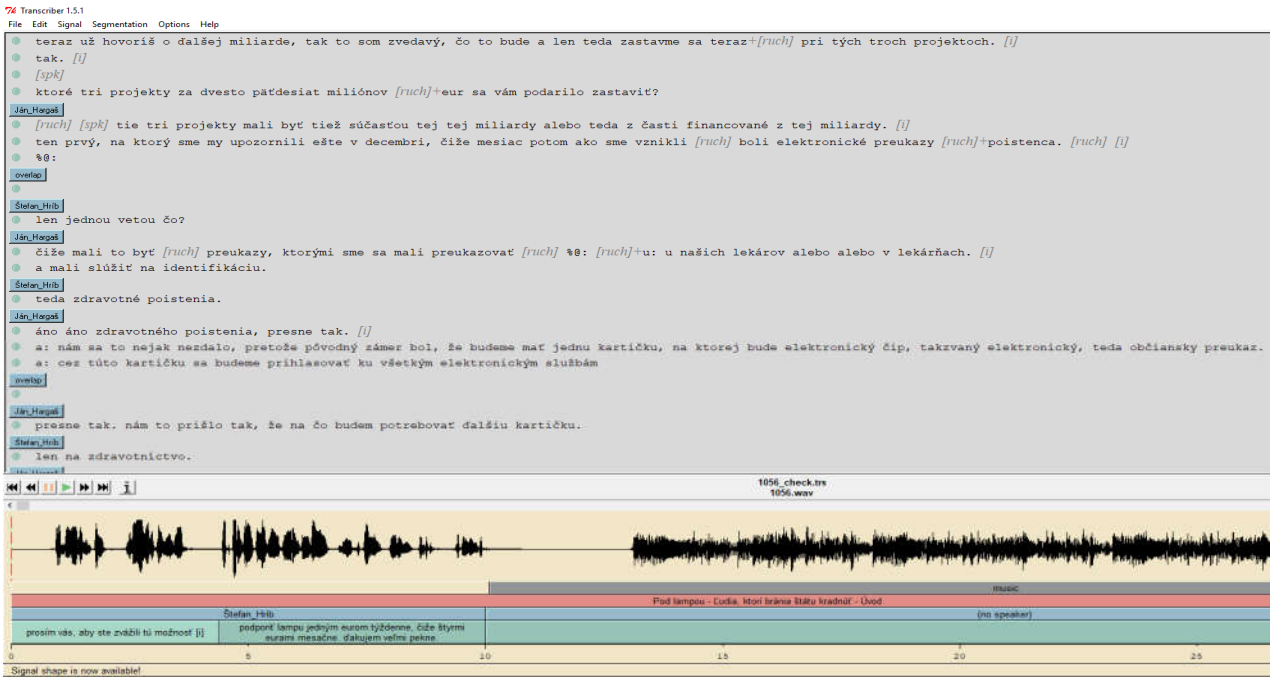

Figure 4. An example of the transcribed recording

its own previous turn)
- Speaker turn leaving misunderstanding
- Obtain agreement
- Express (strong) disagreement
- Express (strong) agreement
- Express involvement

Mentioned categories were statistically evaluated and the results are located in the following tables. Here need to be noted, that in case of reasons categories, one occurrence of overlapping speech can have several reasons.

TABLE I.
TURN-TAKING STATISTICS

Interaction/values	SR175	SR177	1306	Total
Total number of turns	159	107	162	428
No. of 1. speaker turns (moderator)	48	33	55	136
No. of 2. Speaker turns	59	42	70	171
Total No. of overlaps and interruptions	53	31	35	119
Overlaps Ratio	33.3%	28.9%	21.2%	X
No. of 1.speaker overlaps	35	20	X	X
No. of 2. Speaker overlaps	12	11	X	X
1. Speaker overlaps ratio	59.3%	47.6%	X	X
2. speaker overlaps ratio	25%	33.3%	X	X
Mixed overlaps	5%	0%	X	X

TABLE II.
INTERRUPTION AND OVERLAPS MOTIVATIONS

No.	Appearance		
	Category	Occurance	Occ [%]
1.	Stop the speaker	9	4.97
2.	Obtain confirmation	7	3.87
3.	Obtain clarification	11	6.08
4.	Complete the information	13	7.18
5.	Anticipation	42	23.2
6.	Support continuation of speaker turn (backchannel), increase speed of speaker	24	13.26
7.	Express noninterest, move to another topic (topic shift)	12	6.63
8.	Unclear	3	1.66
9.	Try to take floor (back) by force	13	7.18
10.	Provide additional information (to its own previous turn)	15	8.29
11.	Turn leaving misuderstading	10	5.52
12.	Obtain agreement	4	2.21
13.	Express disagreement (strong)	3	1.66
14.	Express strong agreement	8	4.42
15.	Express involvement	7	3.87

V. DISCUSSION

Table I shows statistics about turn-taking in the analysed corpus. We can conclude a significant number of overlaps and interruptions. An average overlaps ratio is around 28%. In a similar analysis, described in [34] by Siegert et al., which was done on Davero corpus (telephony conversations in German), authors obtain 18.9% of overlapping segments. The difference between our observation and Siegert et al. results lies in the fact, that we consider also interruptions without overlapping. Such interruptions can be detected only manually, when the human annotator identifies an unfinished utterance, where it can be anticipated an intention of the speaker to finish his turn. Moreover, Davero corpus consists of interactions, which can be considered as task-oriented.

The next important observation is, that the significantly higher number of interruptions (55 to 23) was made by the first speaker in a role of the moderator. This relates to the role of moderator, which usually lead the interaction and he need to move conversation to obtain desired information or to fulfil the interaction goal.

The second table uncover intentions behind detected overlaps and interruptions. During data analysis we continuously collected possible intentions or reasons, which lead a listener to interrupt the speaker. When we look at collected categories, we can uncover relations to other dialogue-related events and issues.

First of all, several categories identify speech acts/dialogue acts, which are conveyed through utterances that interrupt the speaker turn. Confirmation request, clarification request, Agreement, Disagreement are a typical dialogue acts (see e.g. [35]). Categories: “Stop the speaker”, “Support continuation”, “Move to another topic”, “Try to take floor” can be seen as a turn-management commands, which help to manage speaker changing. We can identify also another category, which has a close relation to providing a feedback (backchannel signals) to the speaker.

Anticipation is a special category, which does not express an intention, but the mechanism behind the interruptions. We were able to identify 42 places, where the listener probably involves his anticipatory capability, to be able to interrupt the speaker before the turn end. We cannot say, that in case of remaining turns, the anticipation was not used, but in the identified cases, applying of anticipation was clear.

VI. CONCLUSIONS

Described research aims to uncover processes behind overlaps and interruptions in a human-human dyadic dialogue interaction, which can bring new ideas for enhancing human-machine dialogue conversation, especially turn-taking. Human-human dyadic interactions were analyzed on the small corpus of interactions, to identify intention of taking a floor by the listener before speaker’s turn end.

Obtained results shown that around 28% of speaker changes are realized through some kind of interruption. This mechanism has its own rules and meaning, and it should be more researched to be able to enhance turn-taking strategies of machines in human-machine interactions.

In case of overlapping segments, anticipation plays an important role, because, a listener needs to process meaning of unfinished speaker turn to be able to produce its own reaction. Fifteen categories of different intentions behind turn-interruptions were identified and the frequency of occurrence were analyzed. The most frequent intention of a listener interruptions was to support continuation and fluentness of the speaker turn (13.26%) by completing last few words of his turn, which was possible thanks to anticipatory capability of the listener.

In case of machines, that will play a role of the moderator of discussions, adding this supporting strategy can significantly increase their conversational skills.

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