Low resource automatic intonation classification using gated recurrent unit (GRU) networks pre-trained with synthesized pitch patterns

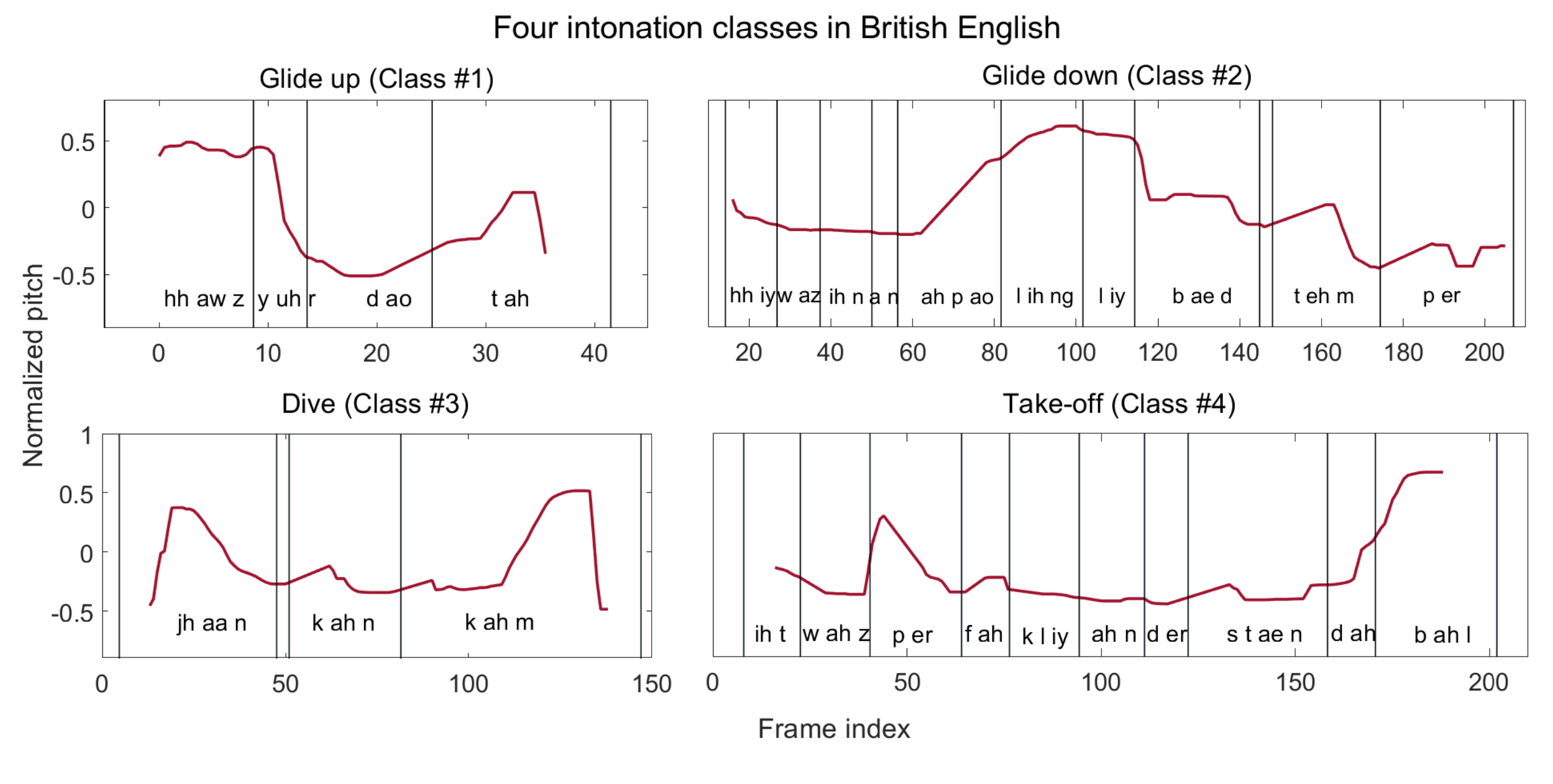
Atreyee Saha[1], *Chiranjeevi Yarra*[2], *Prasanta Kumar Ghosh*[2]

[1]Electrical Engineering, Jadavpur University, Kolkata 700032, India

[2]Electrical Engineering, Indian Institute of Science (IISc), Bangalore 560012, India

Introduction

- Intonation refers to the modulation of pitch in the speech signal.
- It is modelled with temporal structures in either pitch contour or the tone sequence in an utterance.



- Why is intonation important?
  - It is believed to be an emotional indicative of the speaker.
  - For second language (L2) learners, intonation is important in conveying the meaning of an utterance [2].
- Objective:
  - To classify intonation in British English into one of the four classes under a low resource scenario.

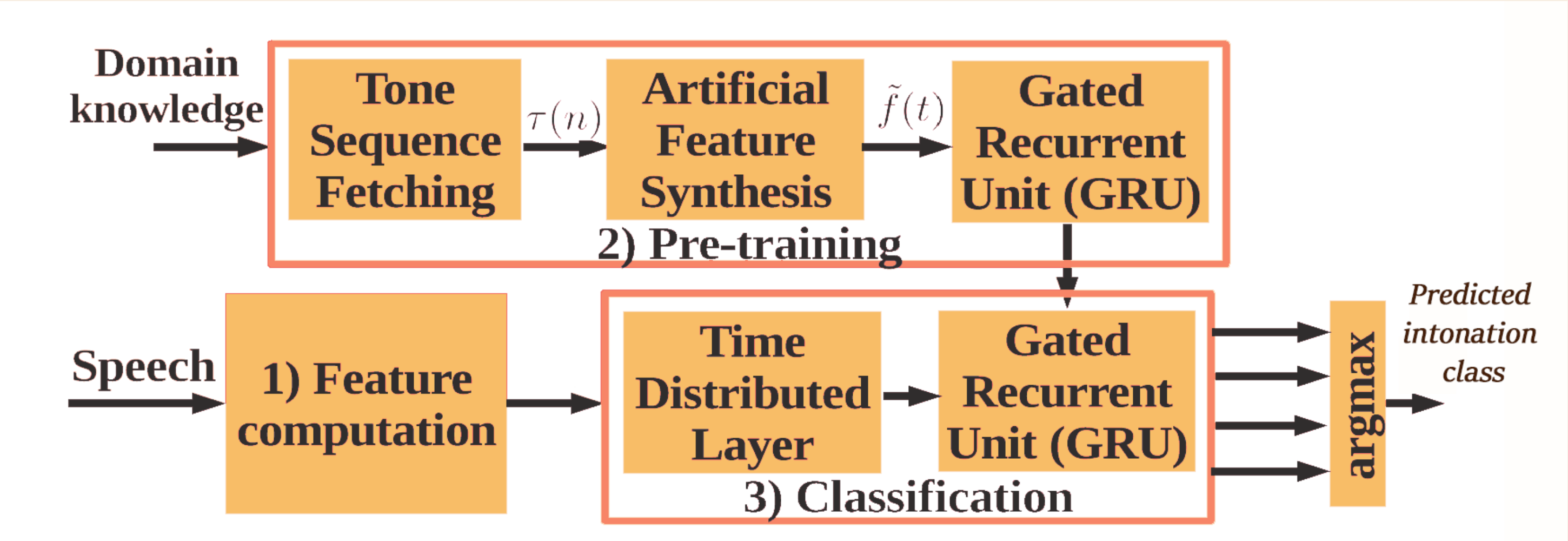
Key contributions

- Handling pitch estimation errors
  - Considered a 3-dimensional feature $f(t) = [f_1(t), f_2(t), f_3(t)]^T$, which includes the confidence score ($f_3(t)$) associated with estimated pitch values ($f_1(t)$). $f_2(t)$ is the first order difference of $f_1(t)$.
- Incorporation of tone sequence modeling
  - Estimation of tone sequence from the text of an utterance is costly and cumbersome and prone to errors.
  - Considered domain specific knowledge in modelling.
- Addressing low resource scenario
  - Proposed a domain specific knowledge based pre-training scheme.
  - Considered a gated recurrent unit (GRU) network, since it involves less number of trainable parameters.

Methodology

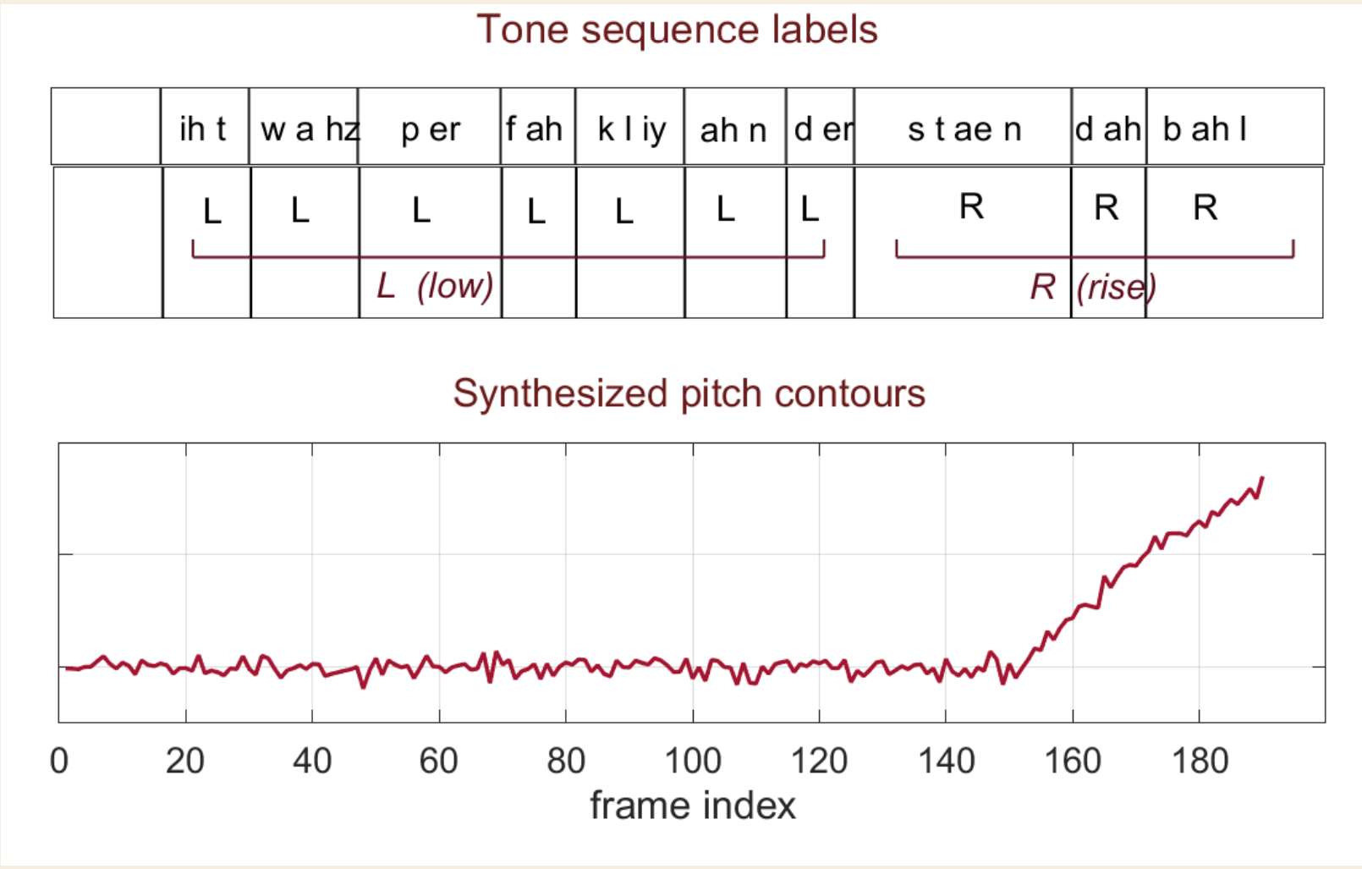
- Tone sequences $\tau(n)$ of each intonation class is collected based on the knowledge of relation between the temporal dependencies in tone sequences and the intonation classes.
- Pre-training is performed using synthetic pitch contours $\tilde{f}_1(t)$ that closely approximate actual pitch contours.
- During training, the weights of the time distributed layer (TDL) are learnt in a way so that the score values are used to minimise the errors in pitch estimation.

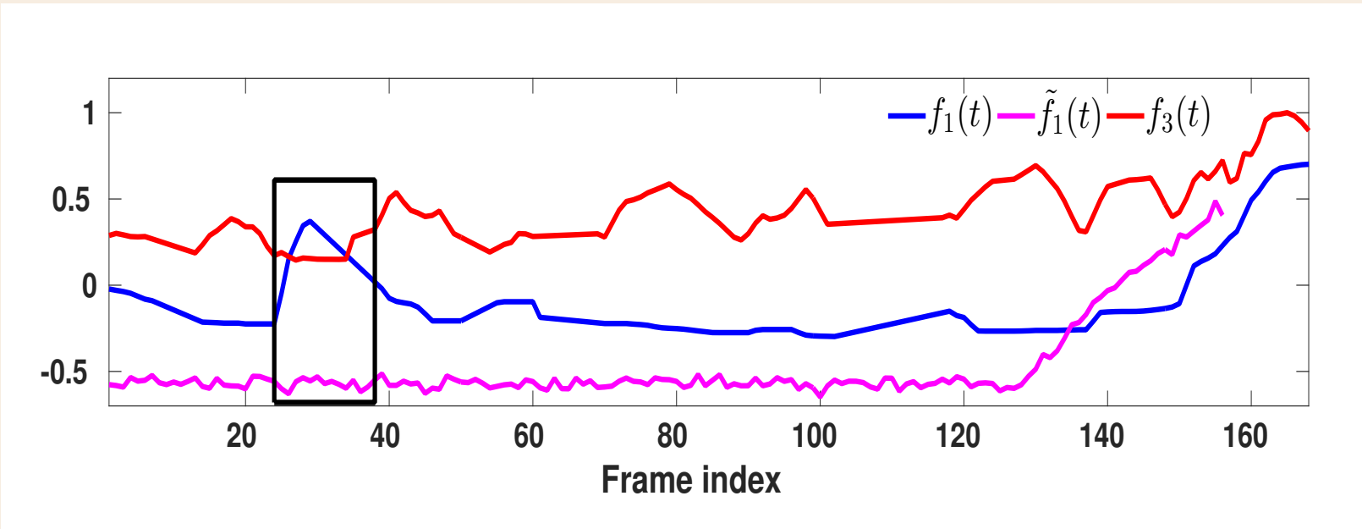
Methodology (contd.)



Proposed Approach

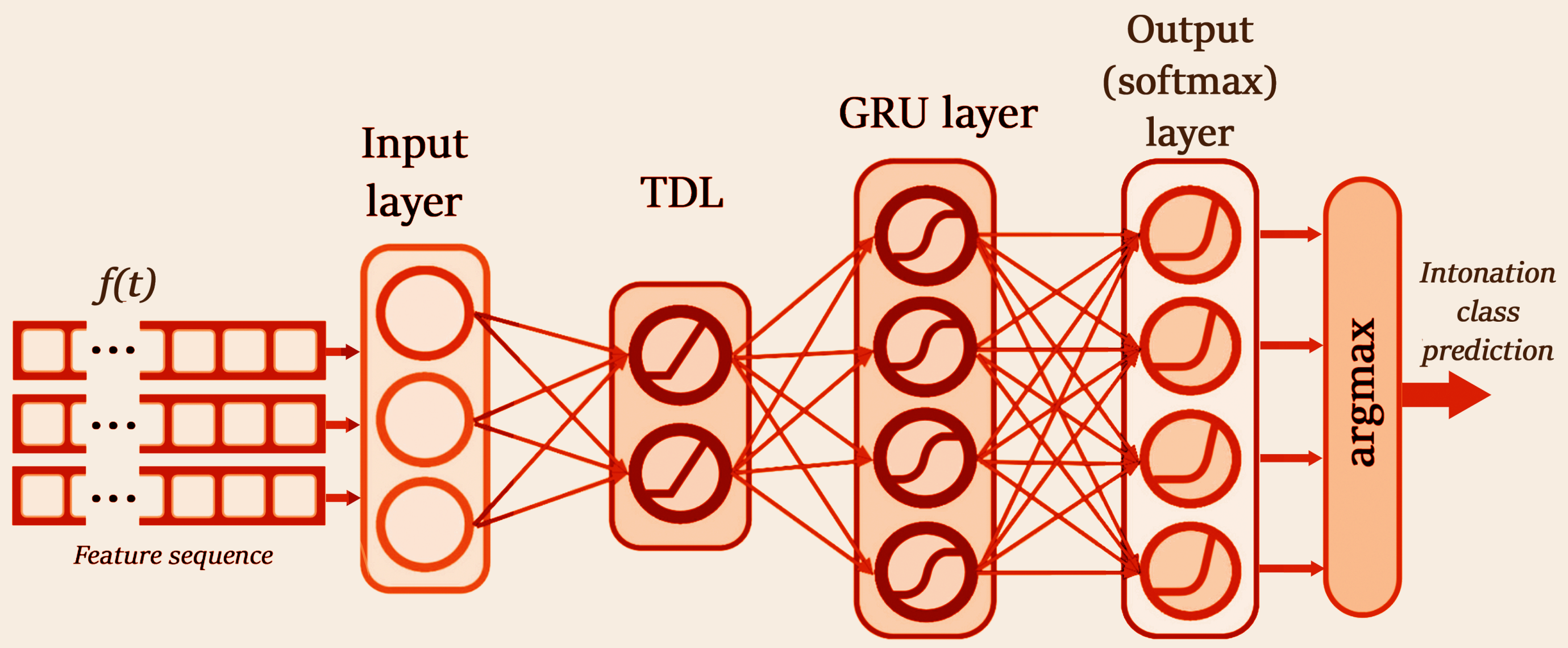
Feature synthesis





- $\tilde{f}_1(t)$ for an exemplary sentence "It was perfectly understandable" belonging to Take-off class.
- Consecutive syllable segments belonging to the same tone form a sub-segment.
- Interpolation is carried out using the individual sub-segments added with Gaussian noise at 20dB SNR.
- It is hypothesized that unwanted errors in pitch estimation are minimized using TDL before applying to GRU network.

Experimental setup



- Speech data is considered from spoken English training material [2] used for teaching British English.
- SWIPE algorithm used to estimate pitch and to obtain confidence scores [3].
- Baseline scheme and $f(t)$ are considered following the work of Yarra *et al.*[1].
- 10-fold cross validation setup.
- The unweighted average recall (UAR) as performance measure.

Results

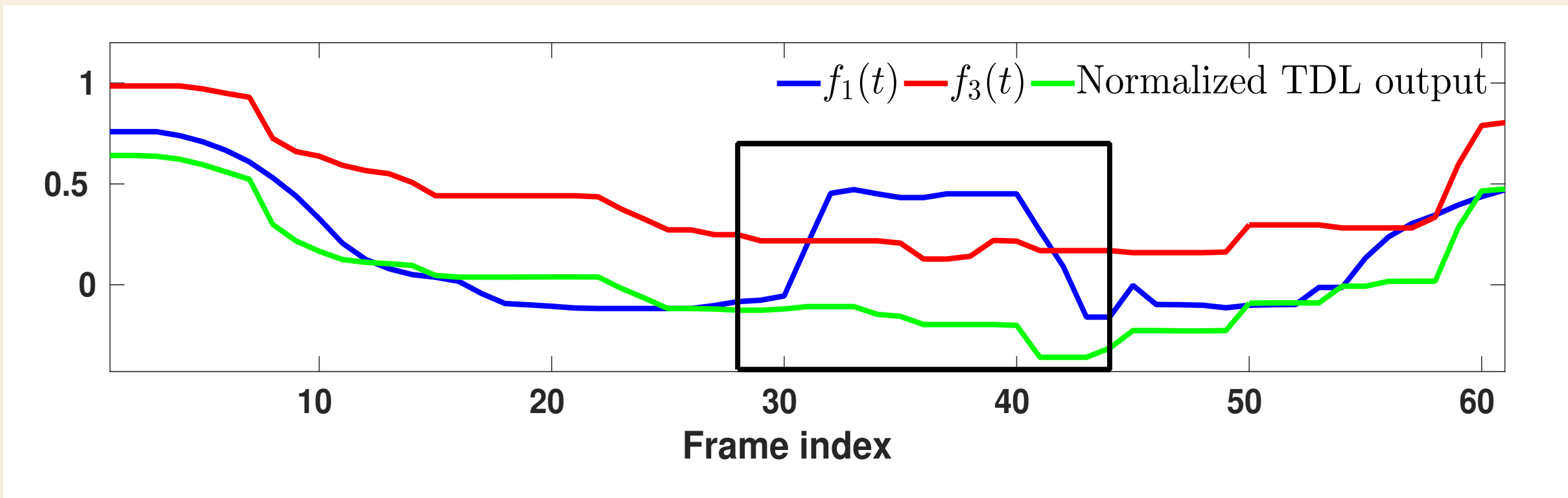
Performance in average UAR (SD)

	Baseline	*Proposed approach*			
		with pre-training		w/o pre-training	
		with TDL	w/o TDL	with TDL	w/o TDL
test	61.77 (8.6)	67.78 (9.8)	63.64 (6.9)	63.54 (5.4)	60.45 (7.3)
dev	62.32 (7.2)	67.73 (8.5)	62.67 (5.5)	63.59 (6.6)	60 (6.0)

Confusion matrix

Class	*Baseline*				*Proposed*			
	#1	#2	#3	#4	#1	#2	#3	#4
#1	62.5	5.00	30.0	2.5	15.0	10.0	70.0	5.0
#2	22.1	61.7	14.5	1.7	3.2	82.5	14.3	0.0
#3	22.2	17.2	54.6	6.0	2.4	14.6	78.1	4.9
#4	0.00	6.7	25.0	68.3	5.7	0.0	17.1	77.1

- The average UAR with the baseline is found to be 6.01% and 5.41% lower than that using the proposed approach on test and development sets respectively.
- Average UARs obtained with the proposed approach are higher when the classifier is pre-trained.
- Significant improvement (decrement) is found in the diagonal (off-diagonal) entries in the confusion matrix with the proposed approach compared to the baseline in all classes except Glide-up.



- Illustration of removal of unwanted pitch estimation errors at the output of TDL.

Conclusion

- Experiments on intonation classification are carried out on British English text implementing GRU network considering pre-training with synthetic pitch contour and input from TDL.
- Overall improvement in the accuracy compared to the baseline scheme.
- Further investigations are required to incorporate complementary properties of the proposed and baseline schemes for satisfactory discrimination between the Glide-up and Dive classes.
- Future works also include the use of linguistic features and data augmentation.

Acknowledgement

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References

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chiranjeeviy@iisc.ac.in, prasantg@iisc.ac.in