

RADE - Machine Learning for Speech over HF Radio

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Supported by a grant from Amateur Radio Digital Communications

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Outline

- 1 Introduction
- 2 Design Versus Training
- 3 RADE Design
- 4 Conclusion

RADE Radio Auto-encoder

- Applying machine learning (ML) to send speech over HF radio
- Combines traditional DSP and modern ML to encode and decode speech
- Connect a PC running RADE to your SSB radio
- 8 kHz audio bandwidth, high quality speech
- Works at low and high SNRs, handles multipath fading

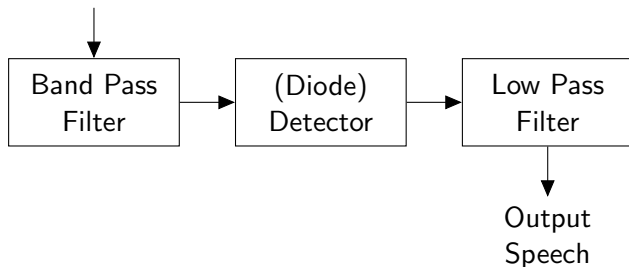
Crowd sourced examples, e.g. Texas to Australia, 25W, SNR 4 dB, deep fading [▶ Link](#)

RADE is an outcome of the FreeDV Project ...

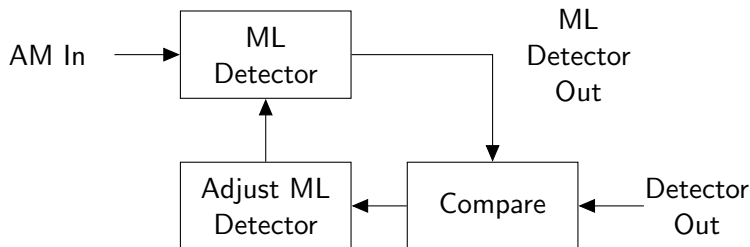
- Open source HF digital voice for amateur radio
- Since 2023, funded by an ARDC grant
- 6 person Project Leadership Team
- Financial sponsor is the Software Freedom Conservancy
- Project Goal: a voice mode competitive with SSB at high and low SNRs

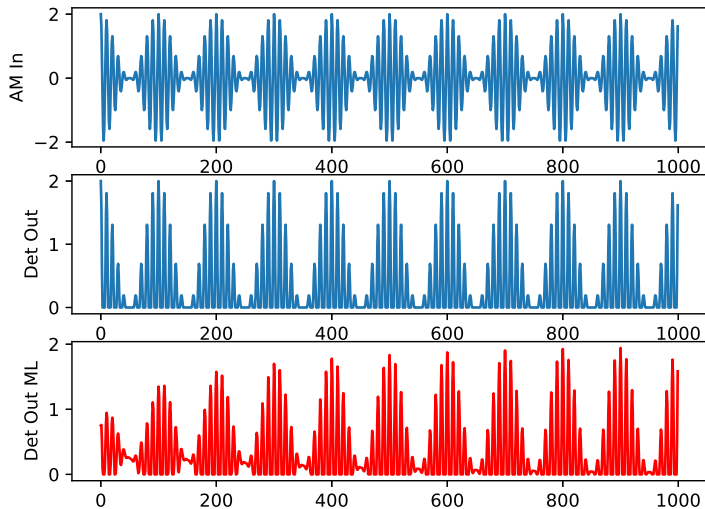
- Previously, we would design a system
- Figure out all the signal processing steps
- With ML the emphasis is on training a neural network
- Consider an AM receiver example
- Lets build the Detector using machine learning

Input RF



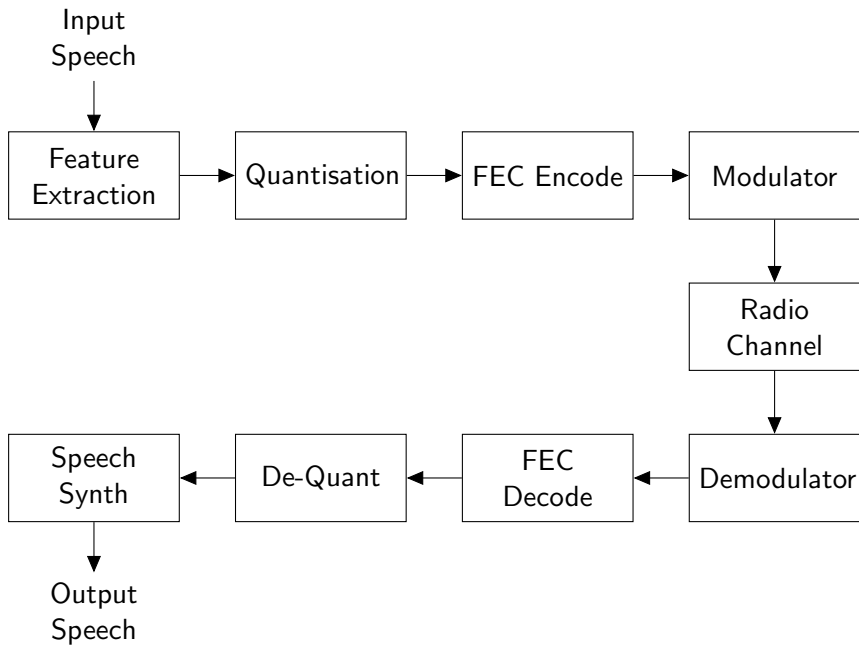
- Start with an untrained neural network
- Collect some training material
- Many examples of input and desired output
- Adjust the network so it matches the desired output

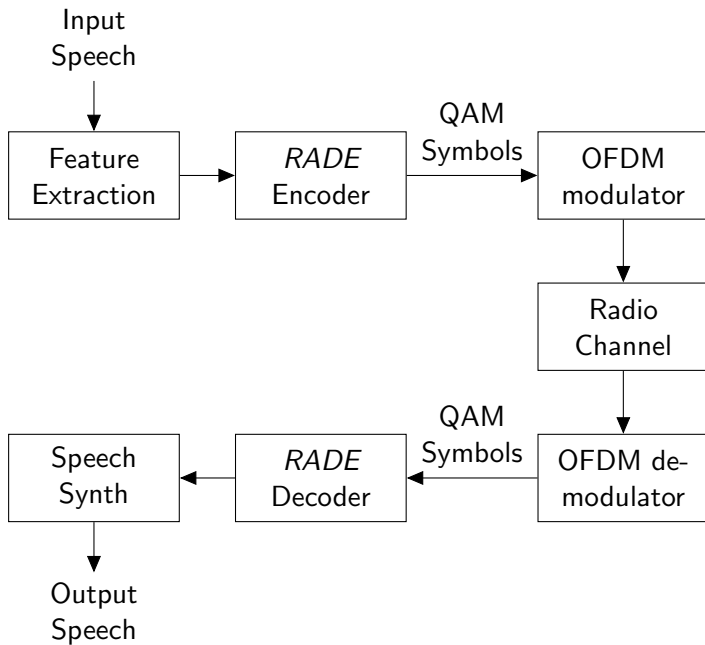




- Sometimes we don't know the best way to design something
- Real world problems are complex, perfect designs don't exist
- But we do have a good idea of what success looks (sounds) like
- So we just treat the system as a black box
- Show it examples of what we would like to see - and train
- ML has provided step changes in performance for many applications
- Including speech synthesis and compression

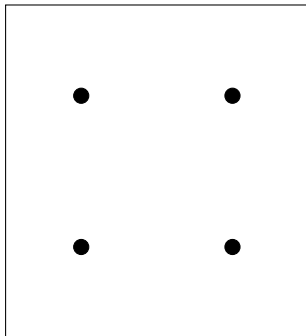
- Jean-Marc Valin (and team) - compressing speech for Internet applications
- Idea: could it could be applied to noisy signal over radio channels?
- Jean-Marc developed a quick proof of concept
- We wrapped a modem around it, developed a practical HF voice system
- Hams around the world helped crowd sourced the testing
- Mooneer Salem integrated RADE with the FreeDV GUI application



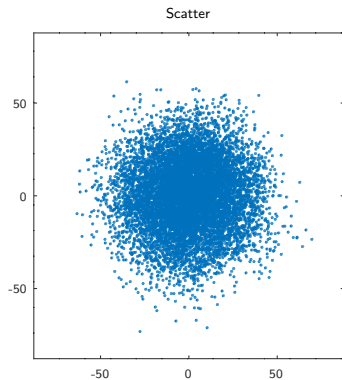


- Example of features - waterfall (aka spectrogram)
- A series of samples of the speech spectrum
- Encoder takes features and produces symbols we send over channel
- Decoder takes symbols and produces features
- Which are fed to a ML synthesiser to generate high quality speech
- Trained with 200 hours of speech, corrupted by noise and the HF channel
- Classical DSP modem wrapped around ML for synchronisation

QPSK Constellation



RADE Constellation



Conclusion

- Training versus Design
- RADE - Radio Autoencoder
- ML combined with classical DSP
- High quality speech over HF at low and high SNRs
- FreeDV GUI Application, sound card, SSB radio
- Supported by a grant from Amateur Radio Digital Communications
- Crowd sourced testing - thanks to many Hams around the world
- Developed by Hams for Hams

Links

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