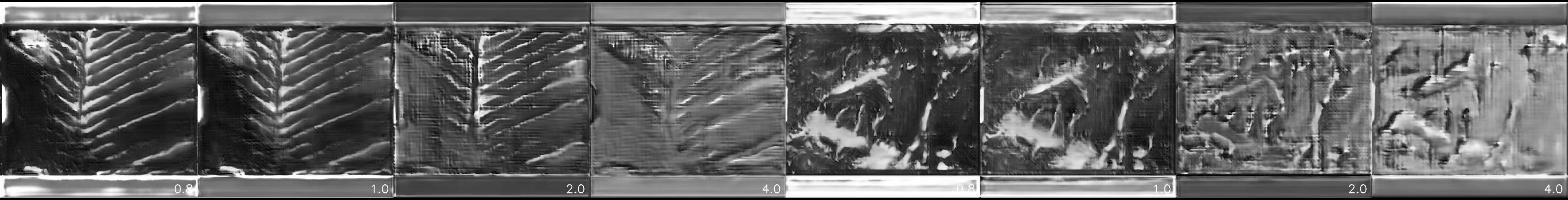
# Exploring Machine Intelligence

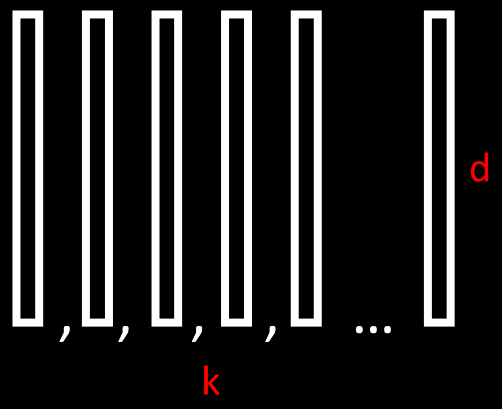
## Week 7, Sequential Modelling




~ Vítek Růžička

# Motivation for today

data in sequence



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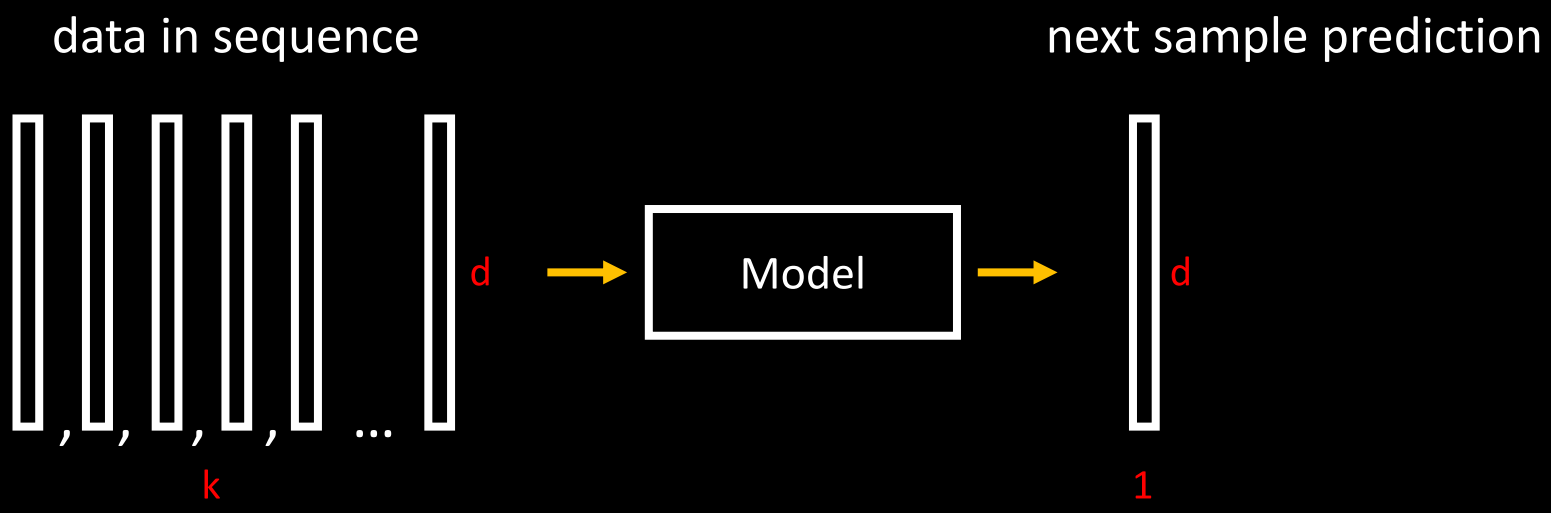

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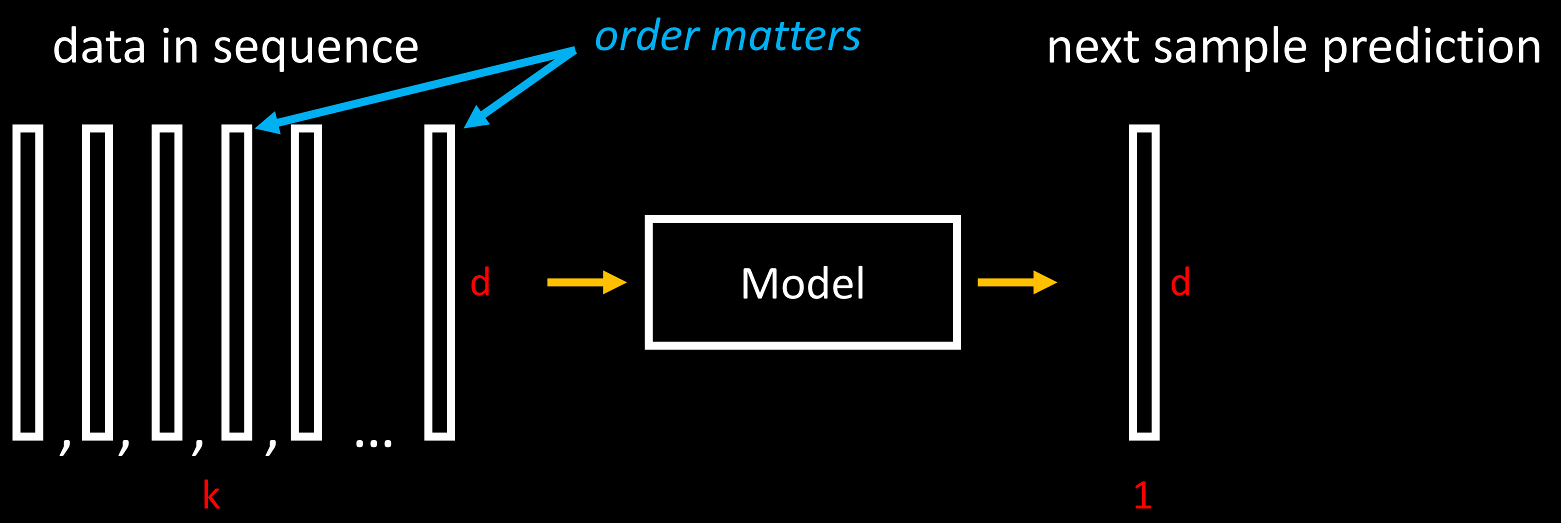

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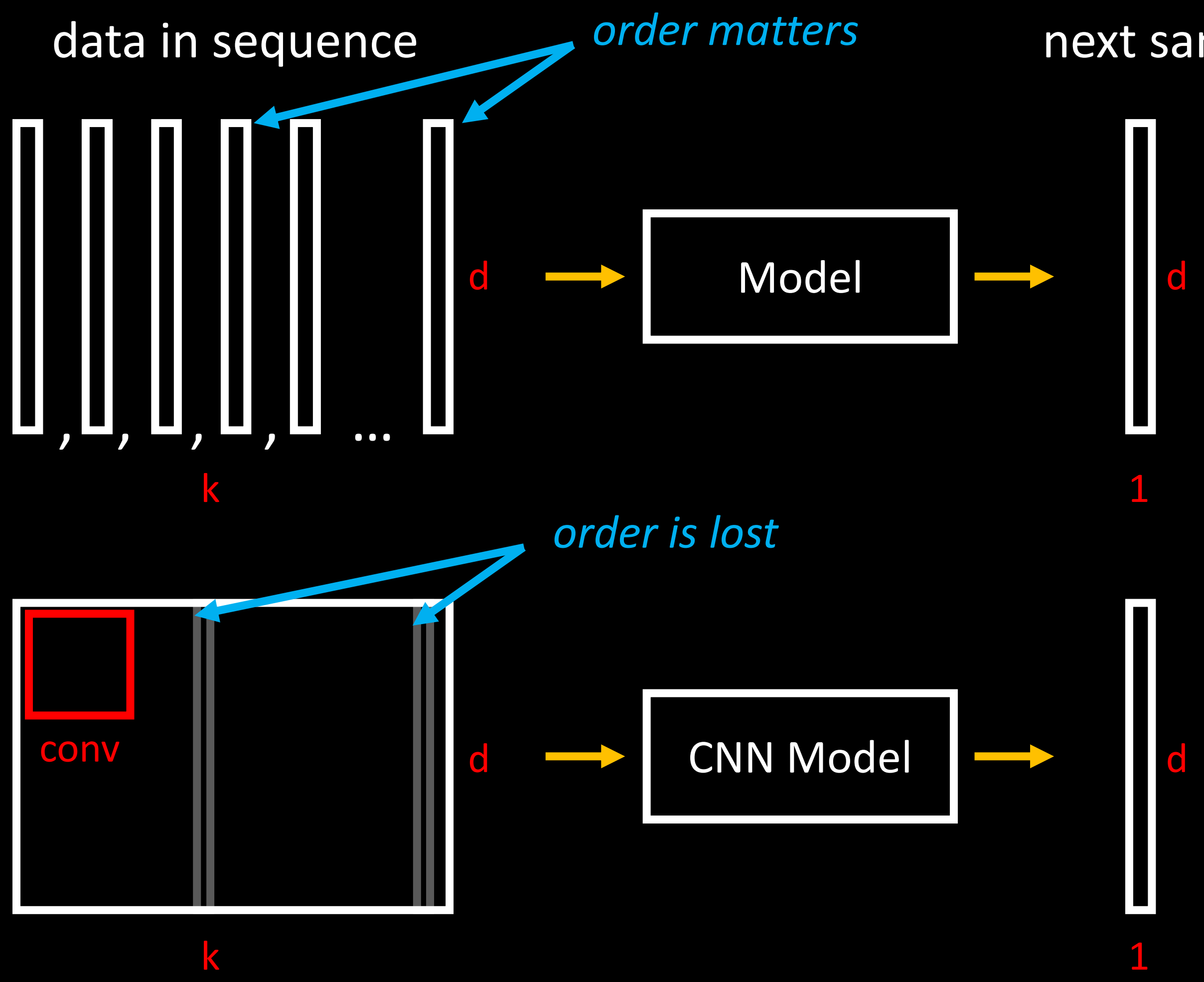
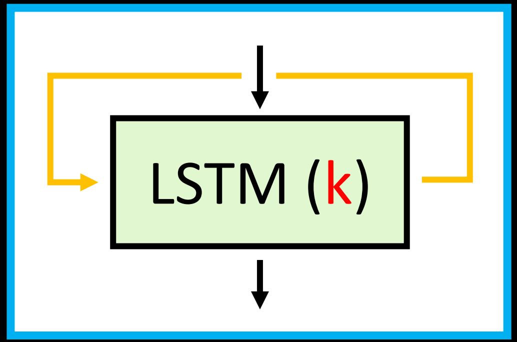



We could use any model we talked about (*CNN, fully connected NN*) to map this data – but there is a **type of models which is designed with sequential data in mind** and maps this sequentiality better.

# Today

**Sequential Modelling**

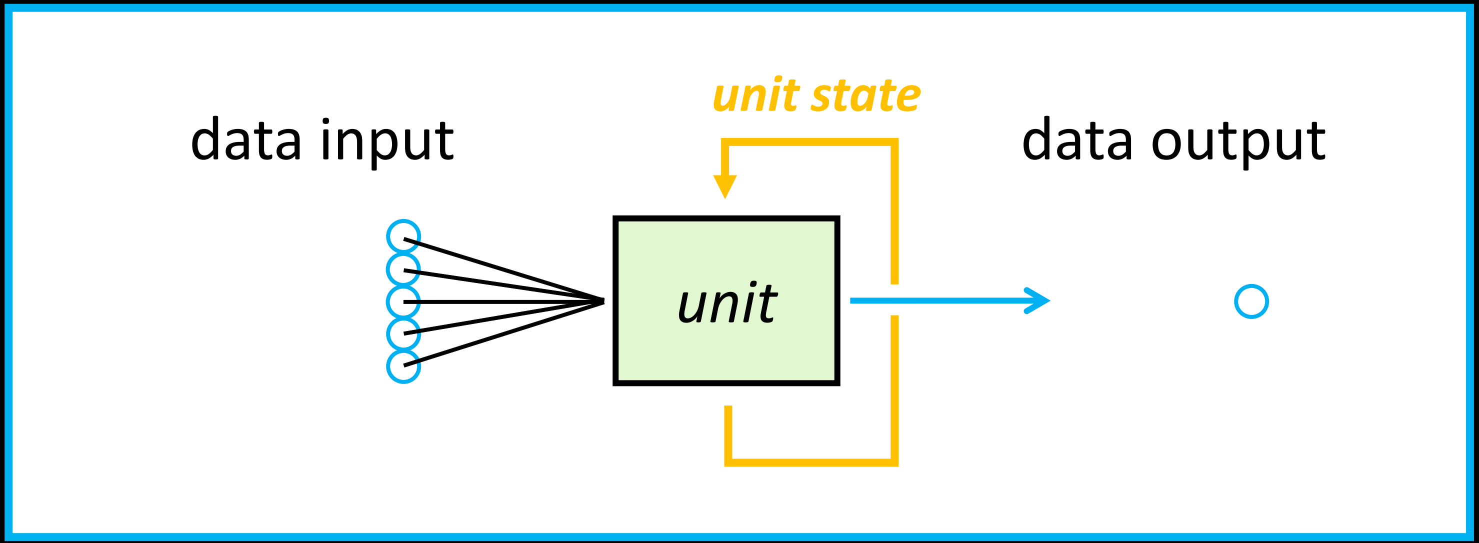
- Creating networks from **units with memory**
- Plugging in **textual and musical data**




**Practical session:**

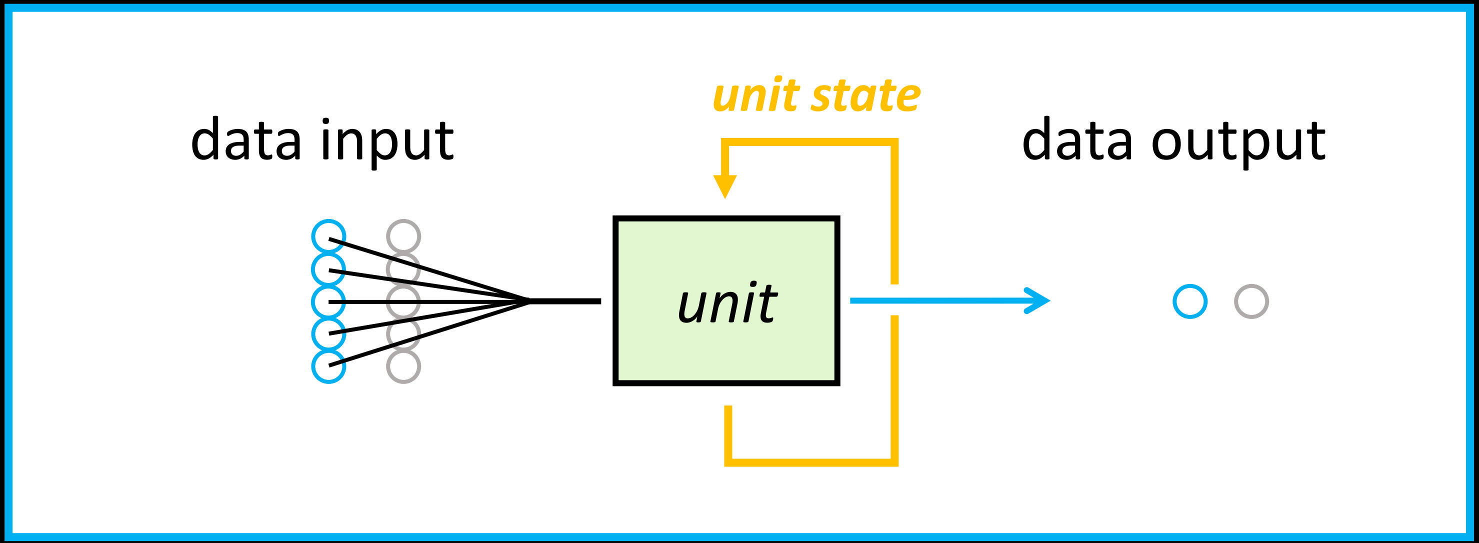
- **Q&A session** for the Final Exam

# Unit with a memory




- Not only we **produce some output from the input**, we also **alter the unit state** (memorize some data from the next input in sequence)
- How both of this happens is something we **learn from the structure of data**

# Unit with a memory

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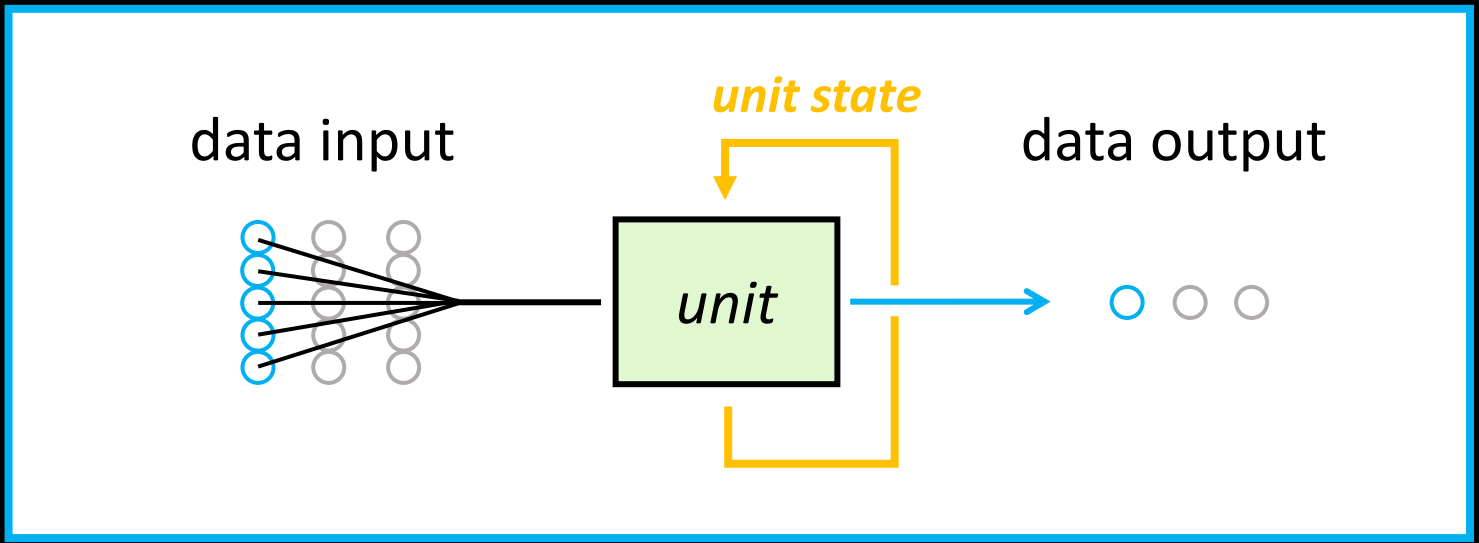
# Unit with a memory

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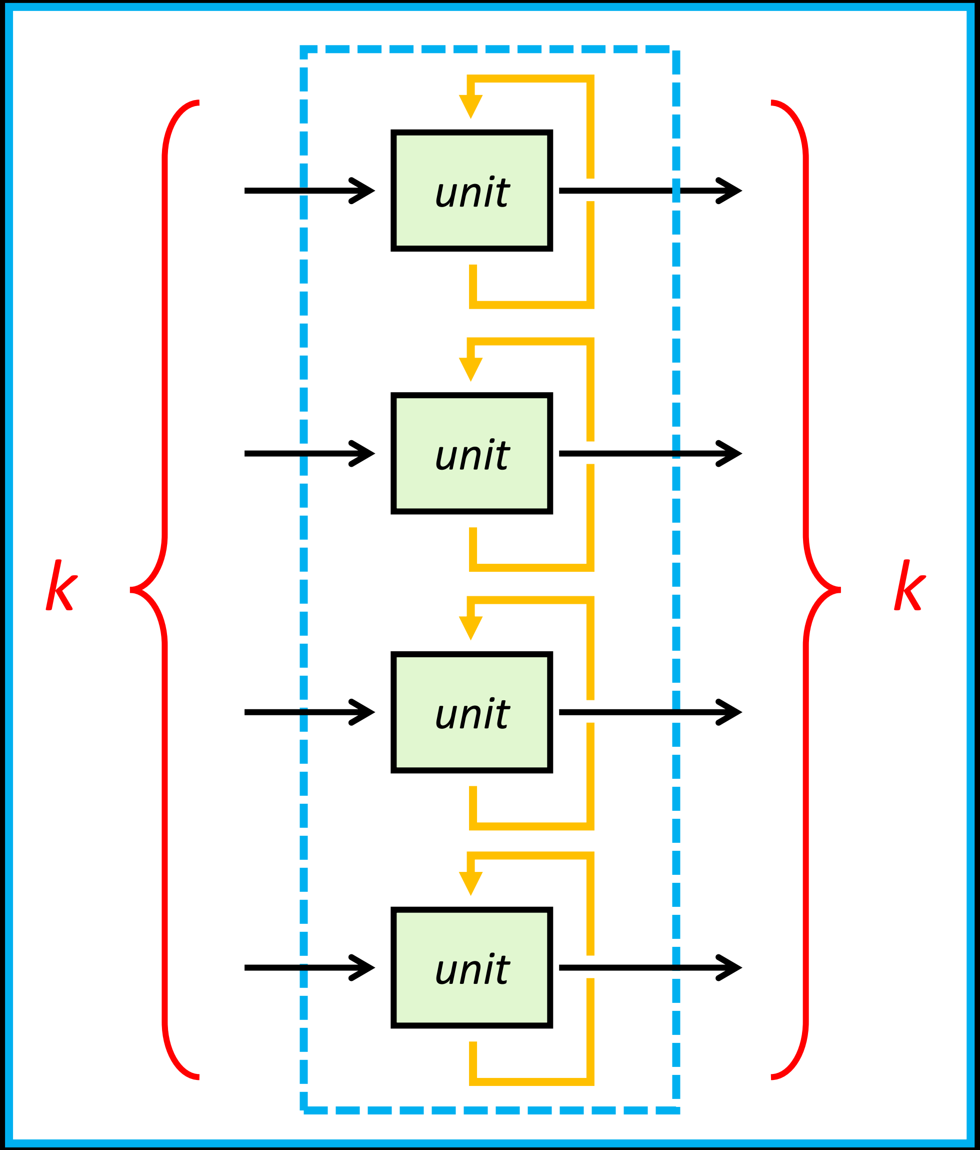
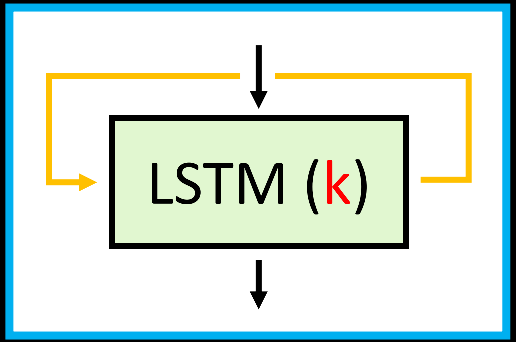
# Recurrent layer

- These **recurrent units** with memory can be put into **layers**

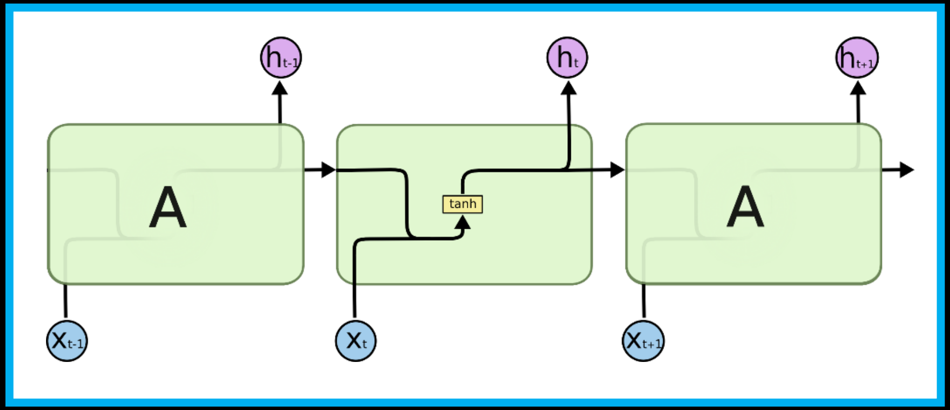



- Single **LSTM layer** with **k** units is usually simplified as:



# Unit types: RNNs and LSTMs

- **Recurrent Neural Networks** (RNN):
  - Simpler unit design



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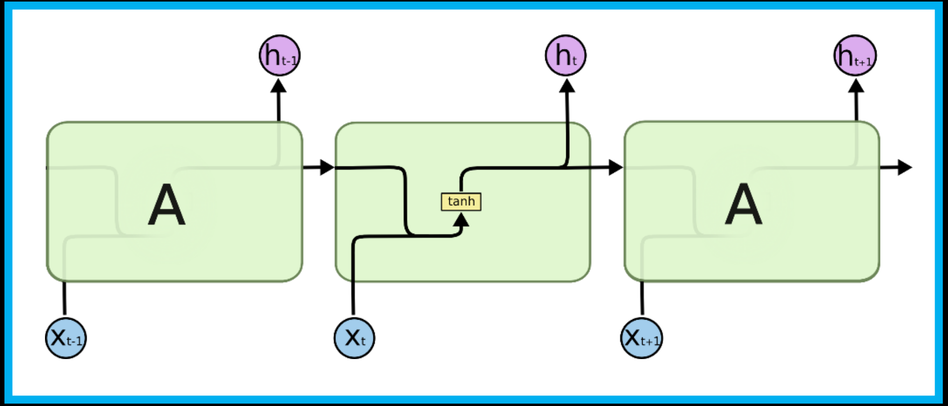


*"I grew up in France... I speak fluent French."*

# Unit types: RNNs and LSTMs

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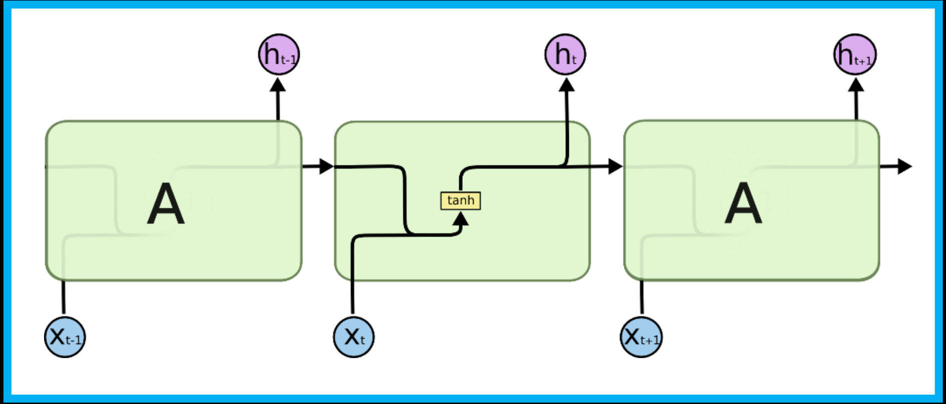
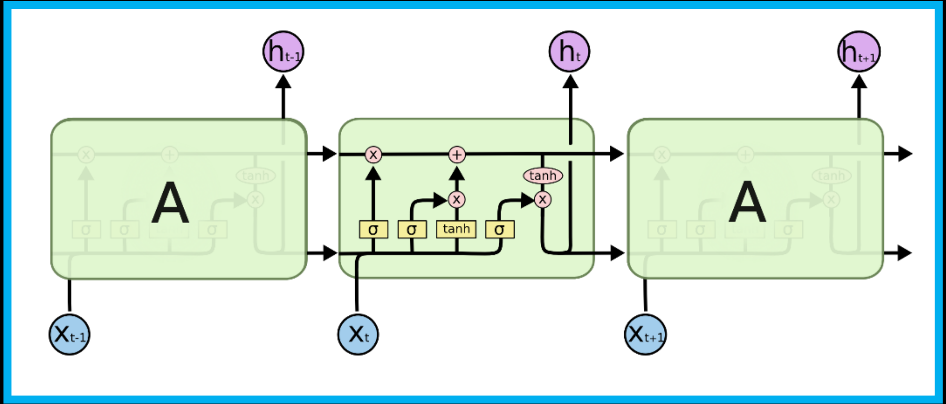



- **Long-Short Term Memory** (LSTM):
  - More complex unit design, made to **remember longer dependencies** inside the data




*^ forget and input gates controlled by learned parameters (hence needs more of them)*

*"I grew up in France… I speak fluent French."*

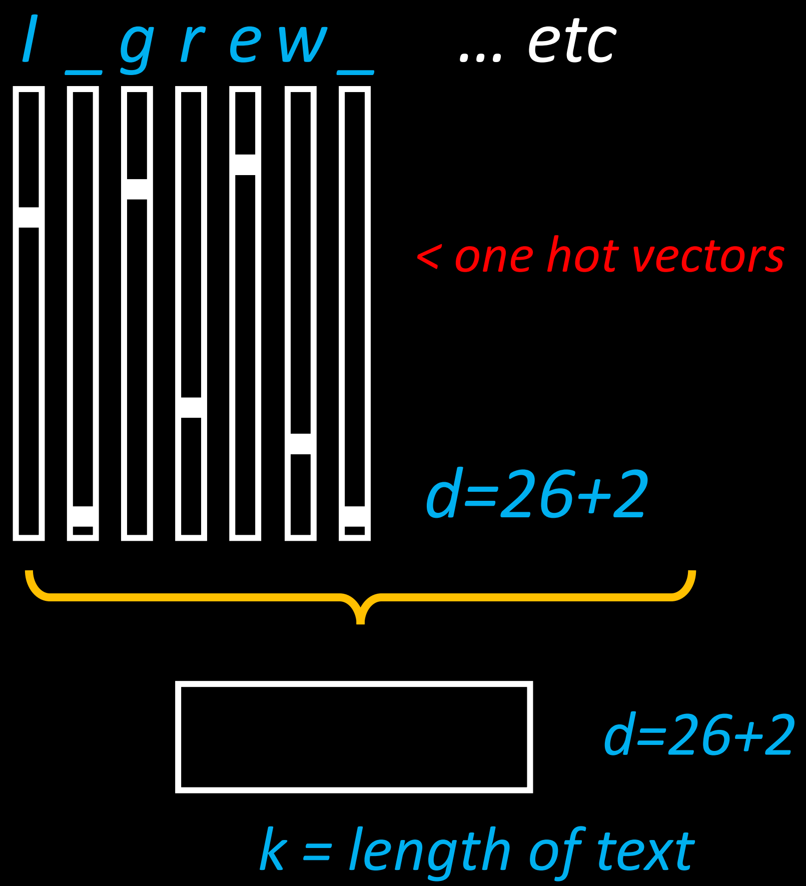
# Plugging in text data

*“I grew up in France… I speak fluent French.”*

- **Vectorize text using a dictionary**

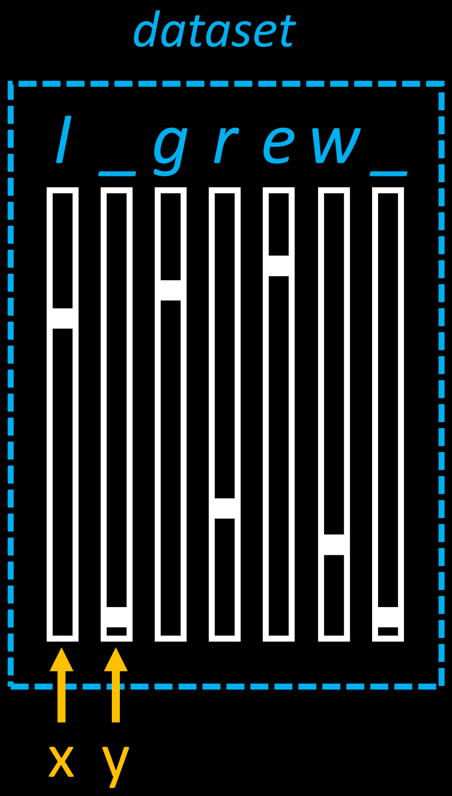
# Plugging in text data

*"I grew up in France… I speak fluent French."* *< original data*

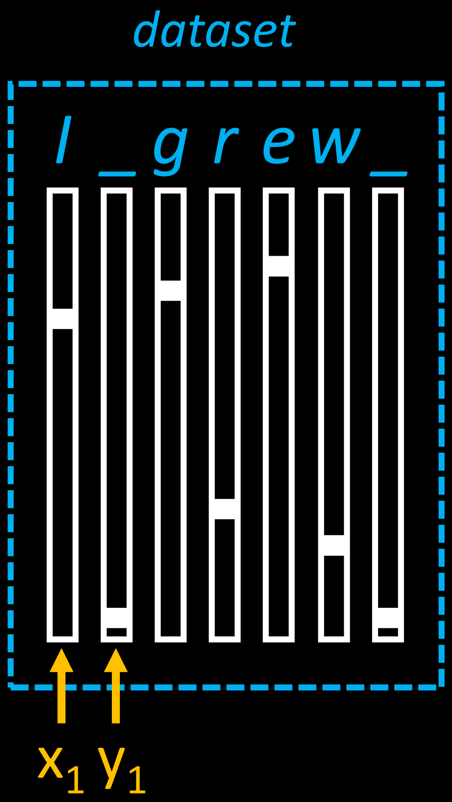


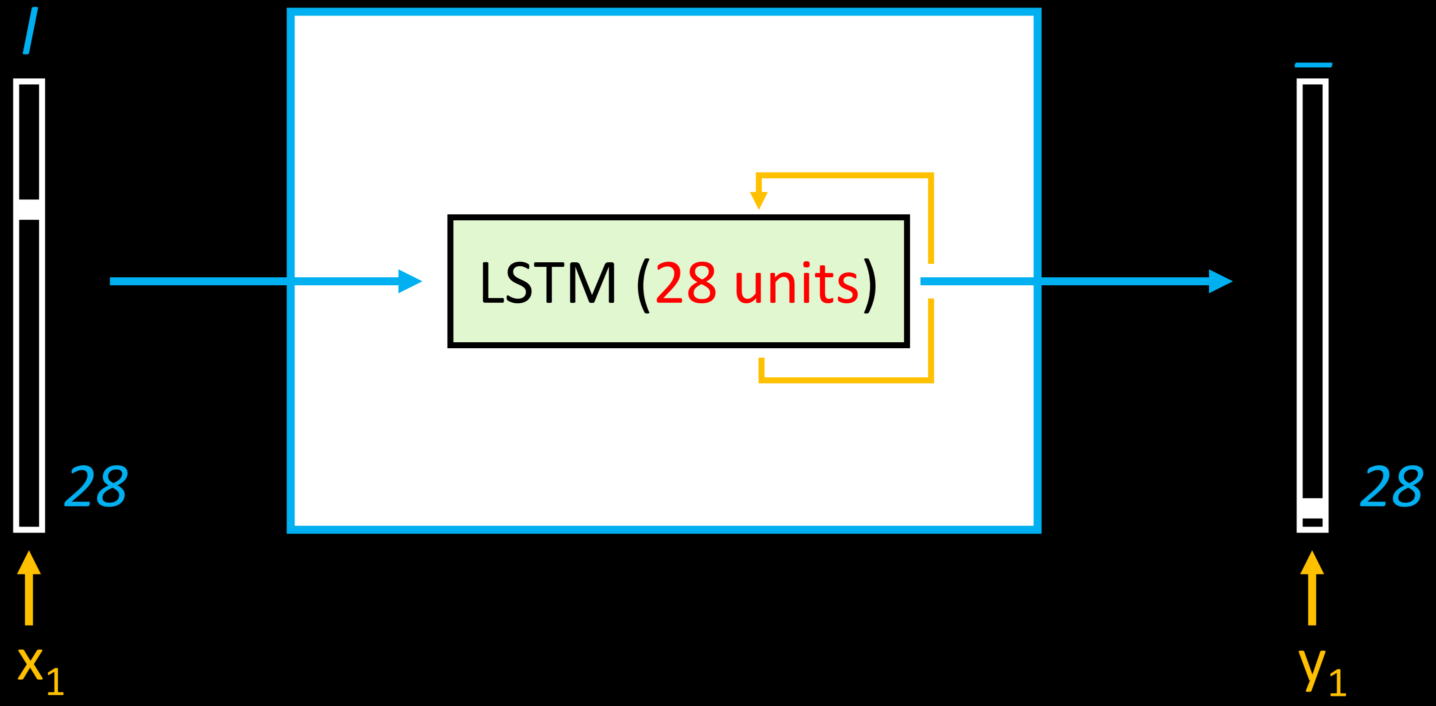

- **Vectorize text using a dictionary**
- Each letter is **encoded as a one-hot vector** using alphabet as dictionary (or full words using a word dictionary)
- We can **later decode the predictions** looking into that dictionary

# Simple model



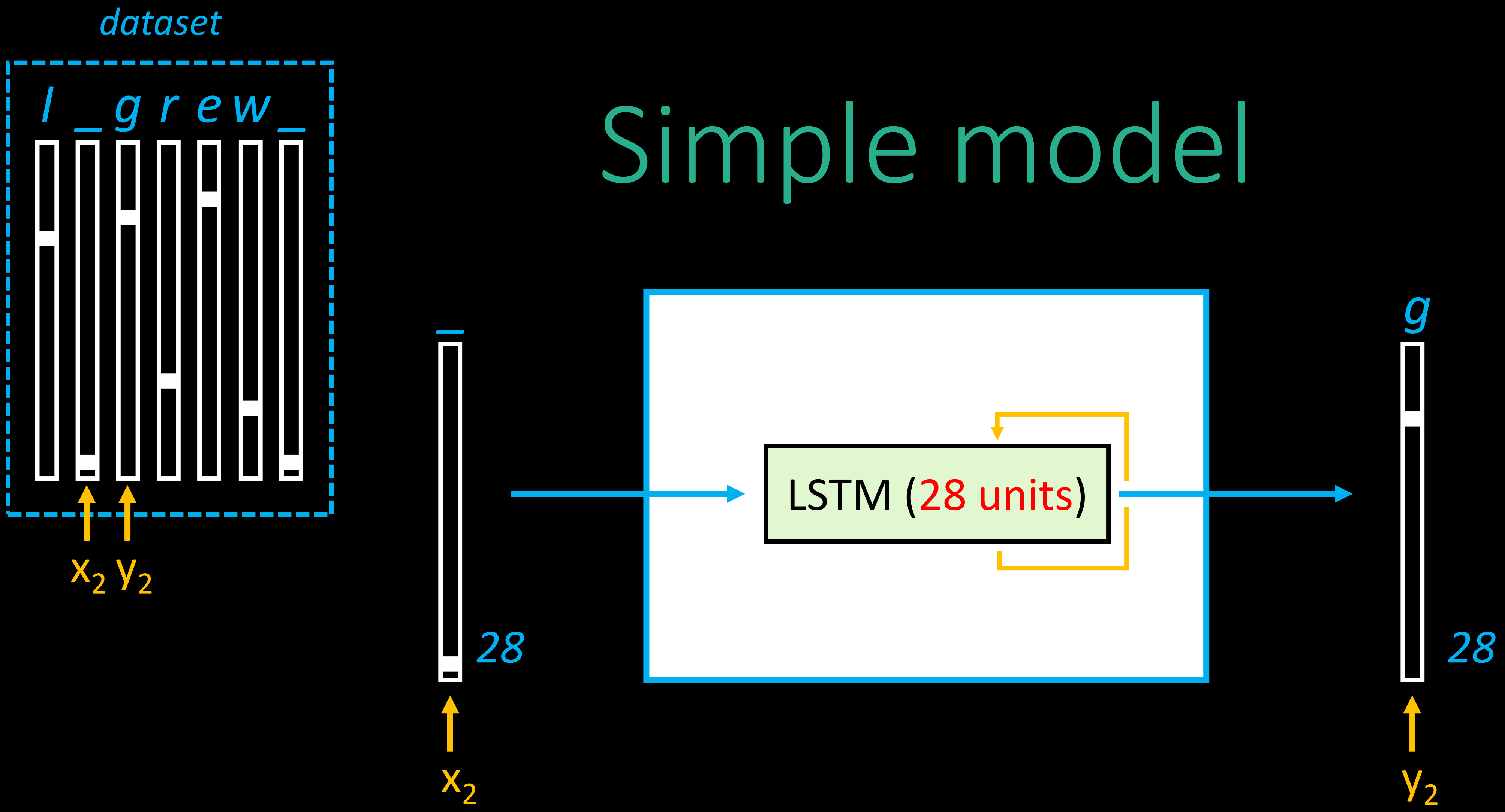
# Simple model



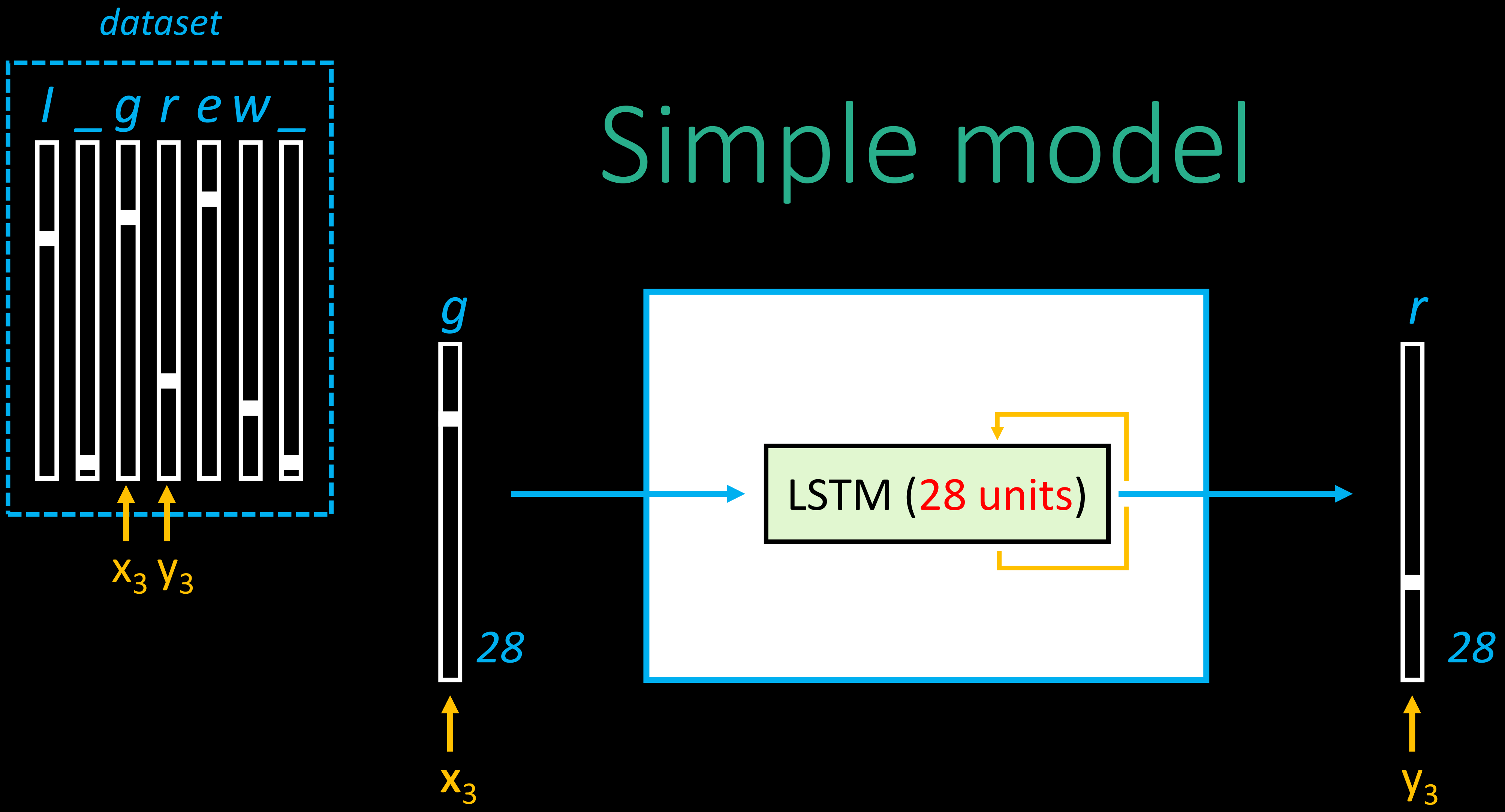

- We are **training the model** to **learn the transformation x -> y** while it also **learns what** is useful **to save** inside the 28 units (what preceded before this x).

# Simple model




- We are **training the model** to **learn the transformation x -> y** while it also **learns what** is useful **to save** inside the 28 units (what preceded before this x).

# Simple model




- We are **training the model** to **learn the transformation x -> y** while it also **learns what** is useful **to save** inside the 28 units (what preceded before this x).

# Text data

- Example:

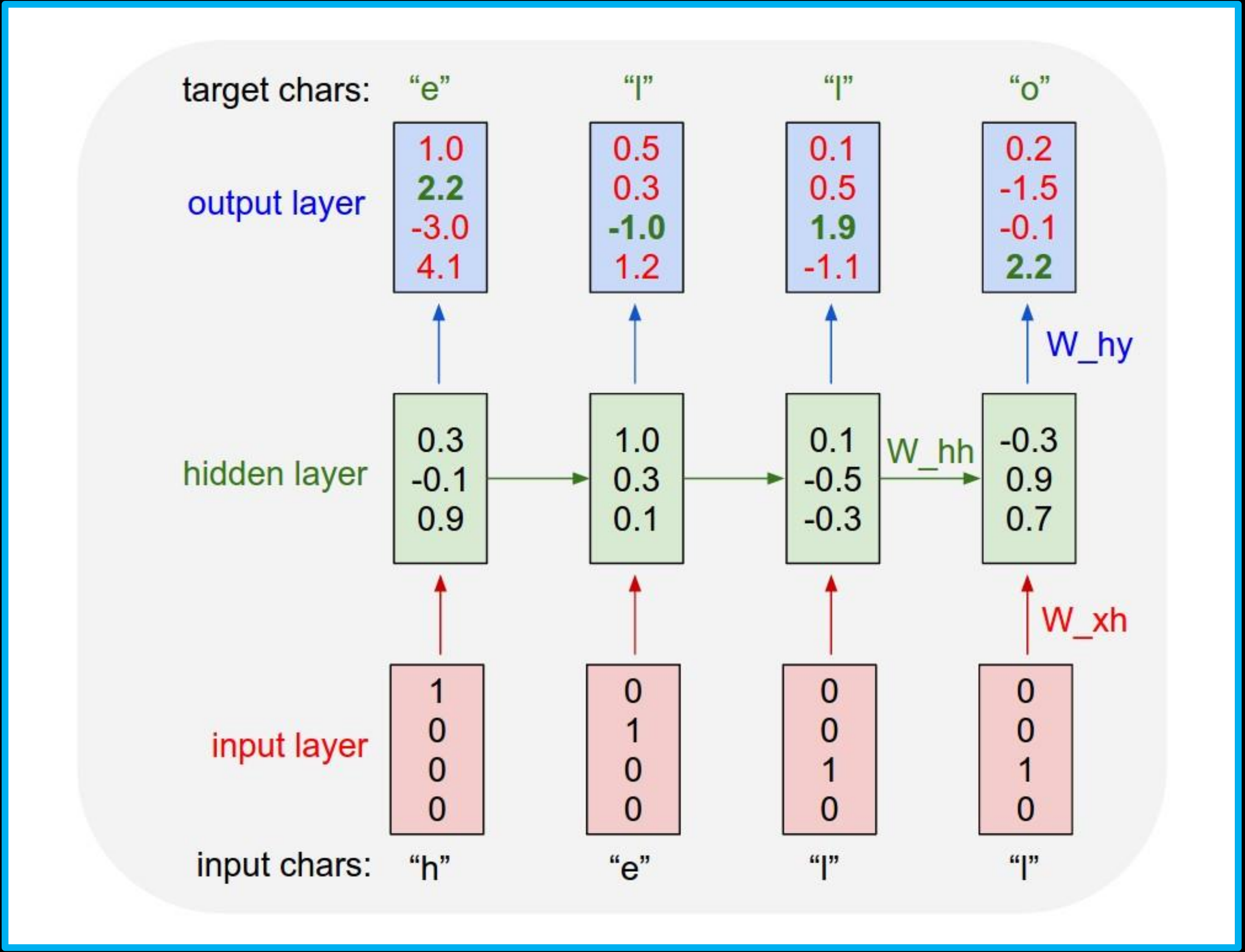
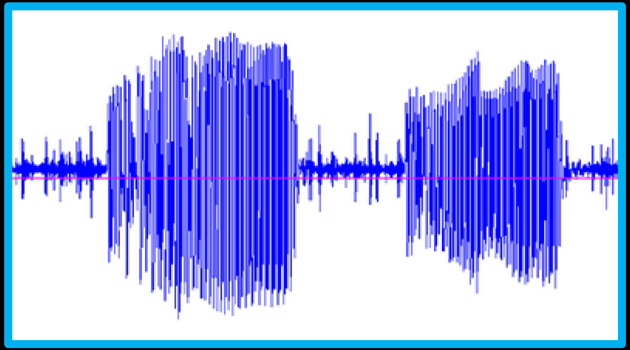



Illustration: [blog]

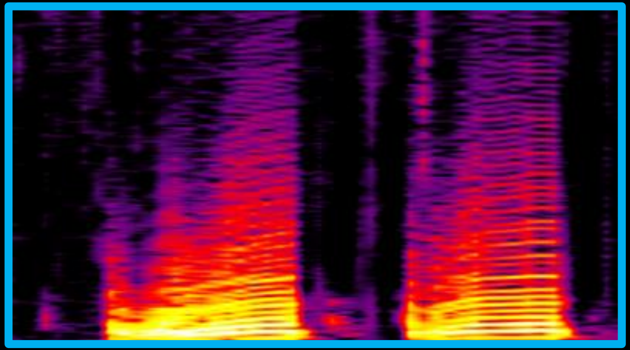
# Plugging in music data

*original data*



***fft*** →

*spectrograms*

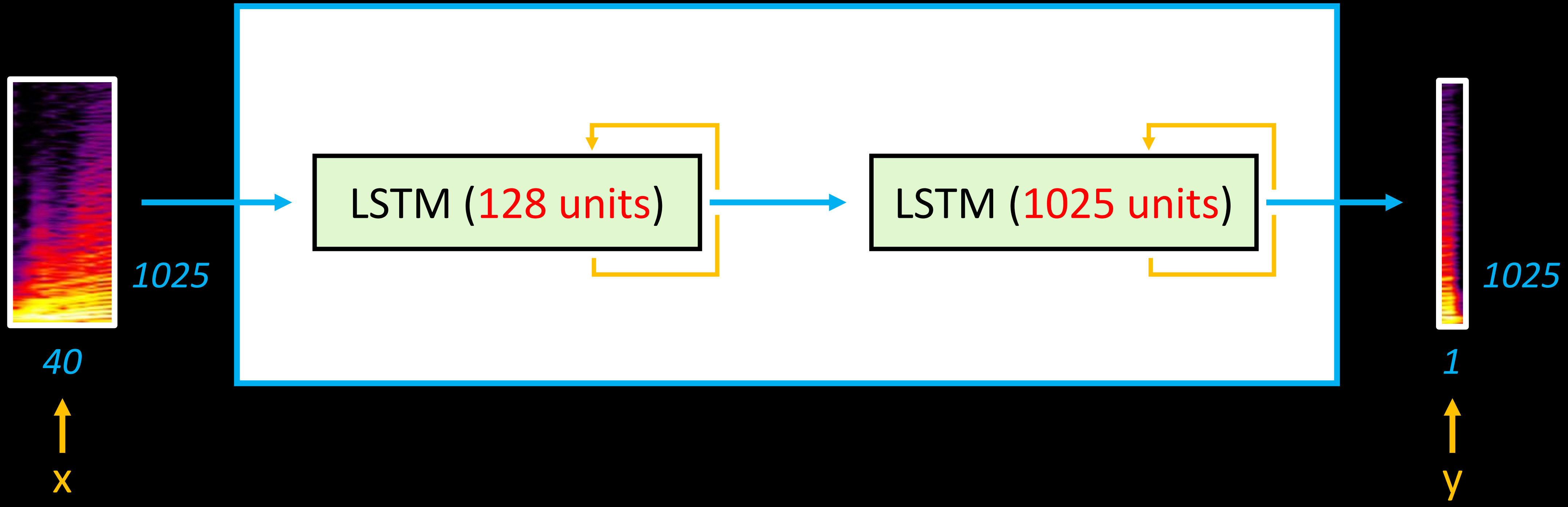


***d** = 1025*

***k** = number of frames*

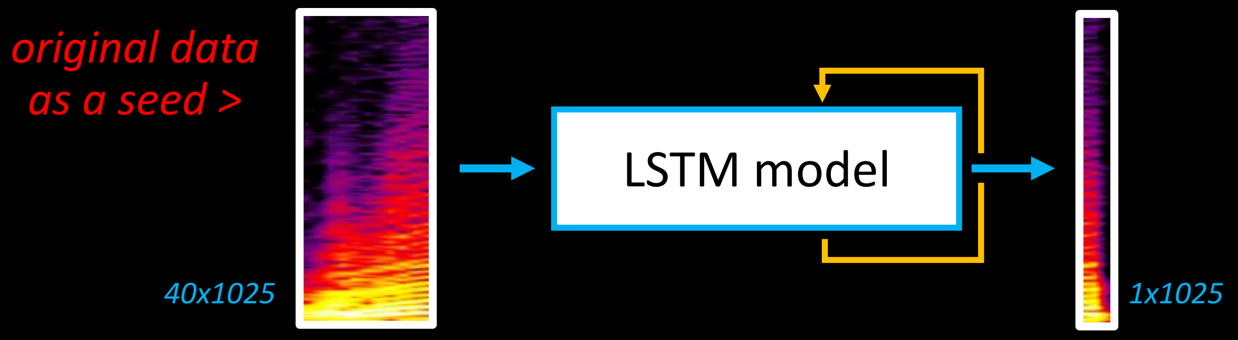
- **Encode music using the Fourier Transform** (*fft*) to get **spectrogram** (which can be considered as image representation)
- We can **later decode the predictions** using the *inverse fft*

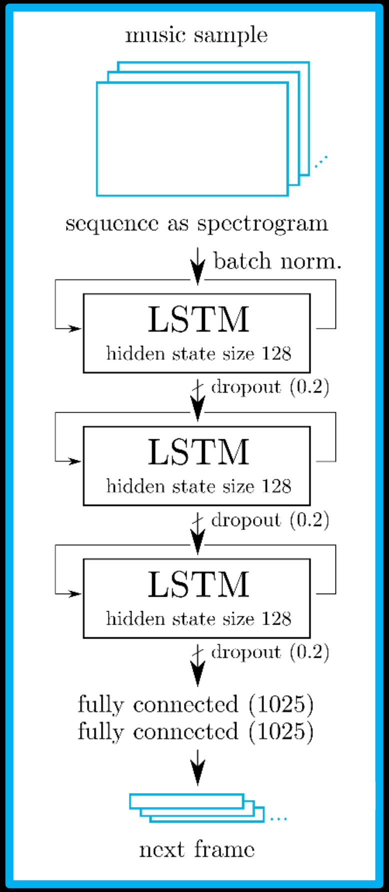
# Larger model




- We are **training the model** on a longer sequence of data (*"many to one"*), the model still **learns the transformation** of **x -> y**.

# Using a trained LSTM model:



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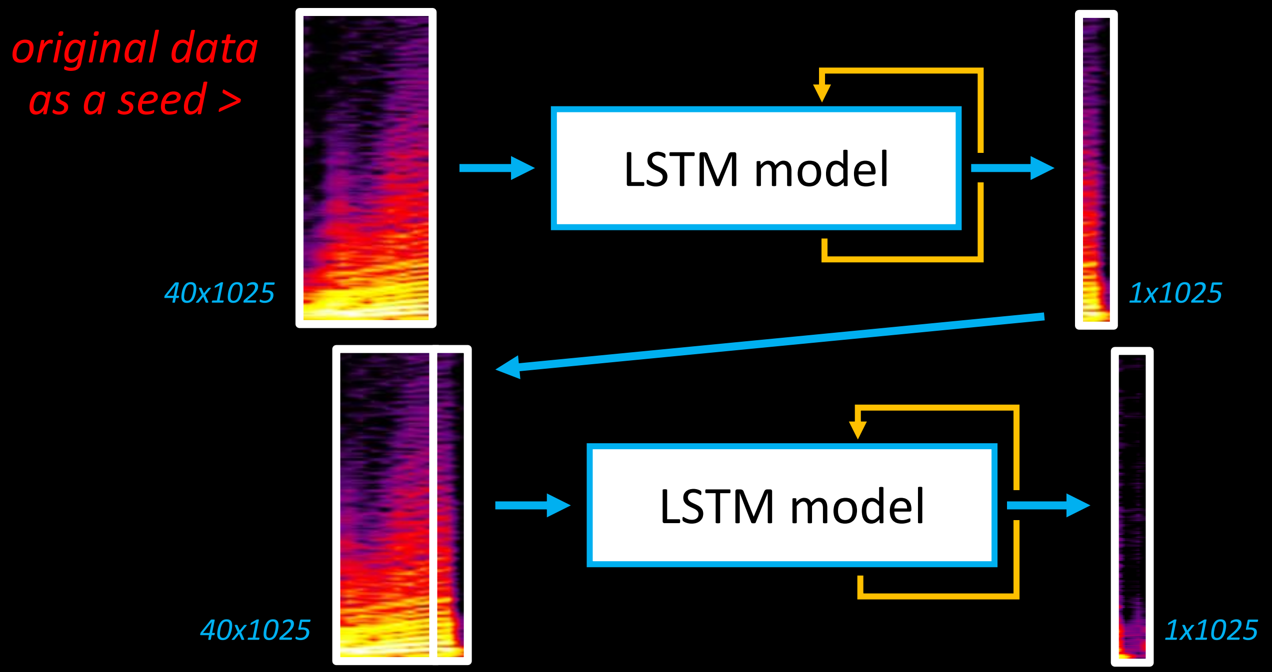


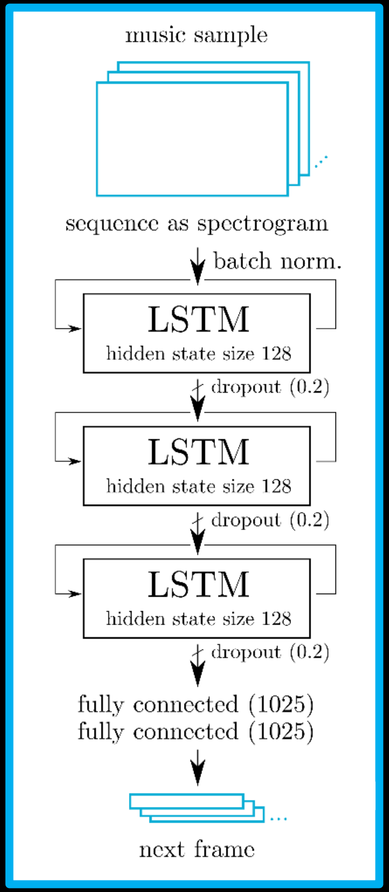

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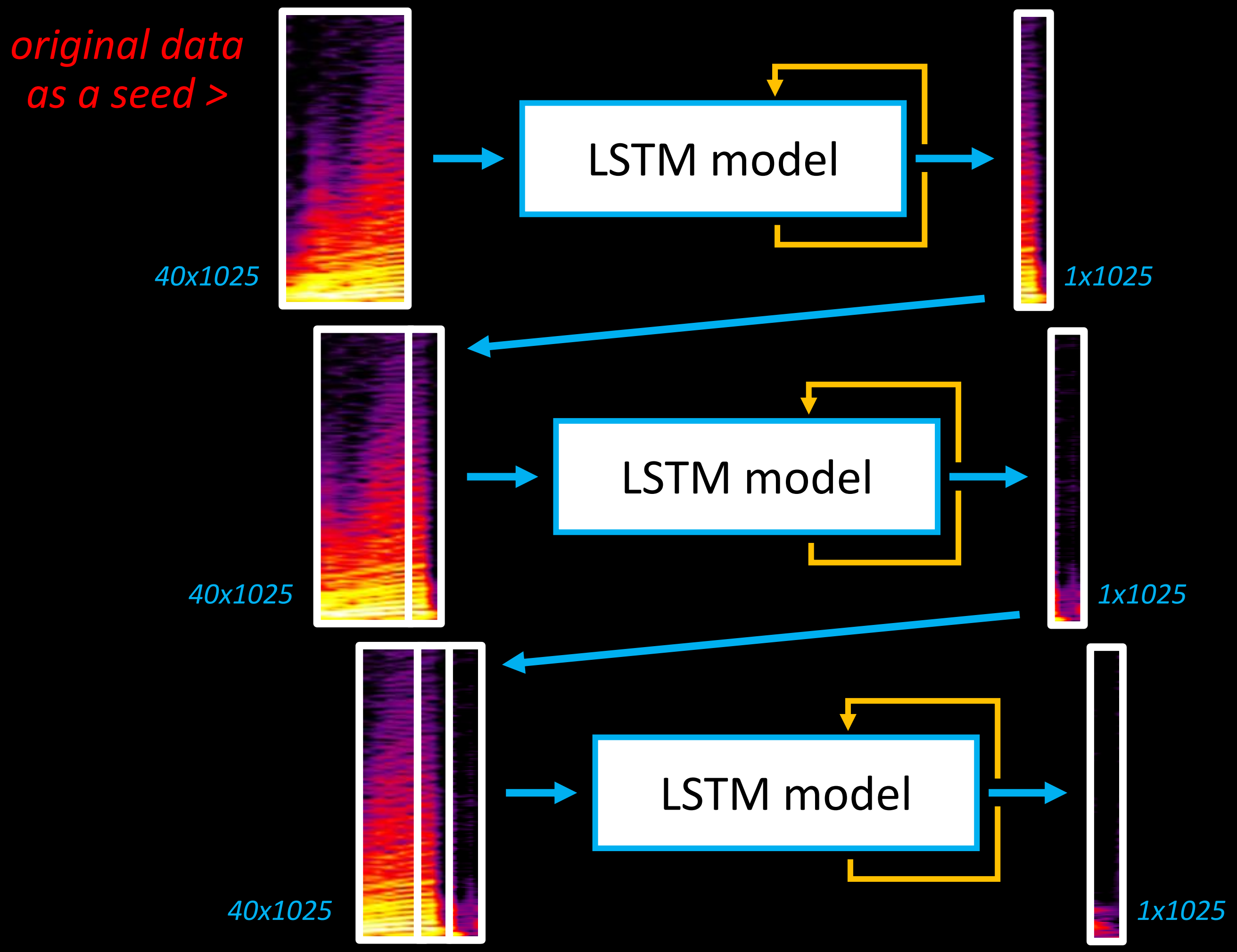
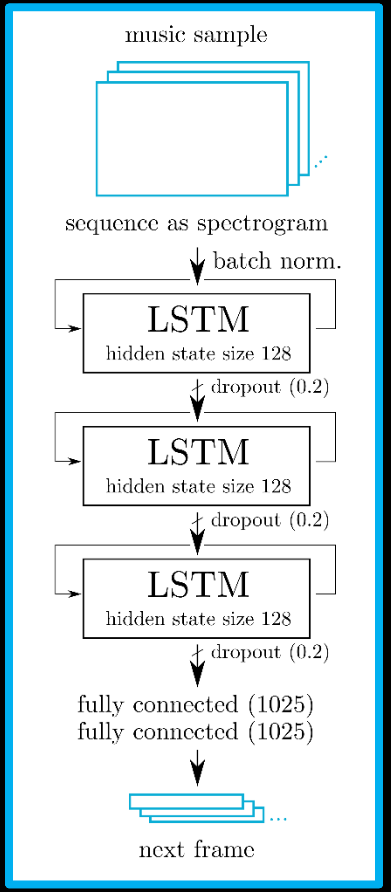
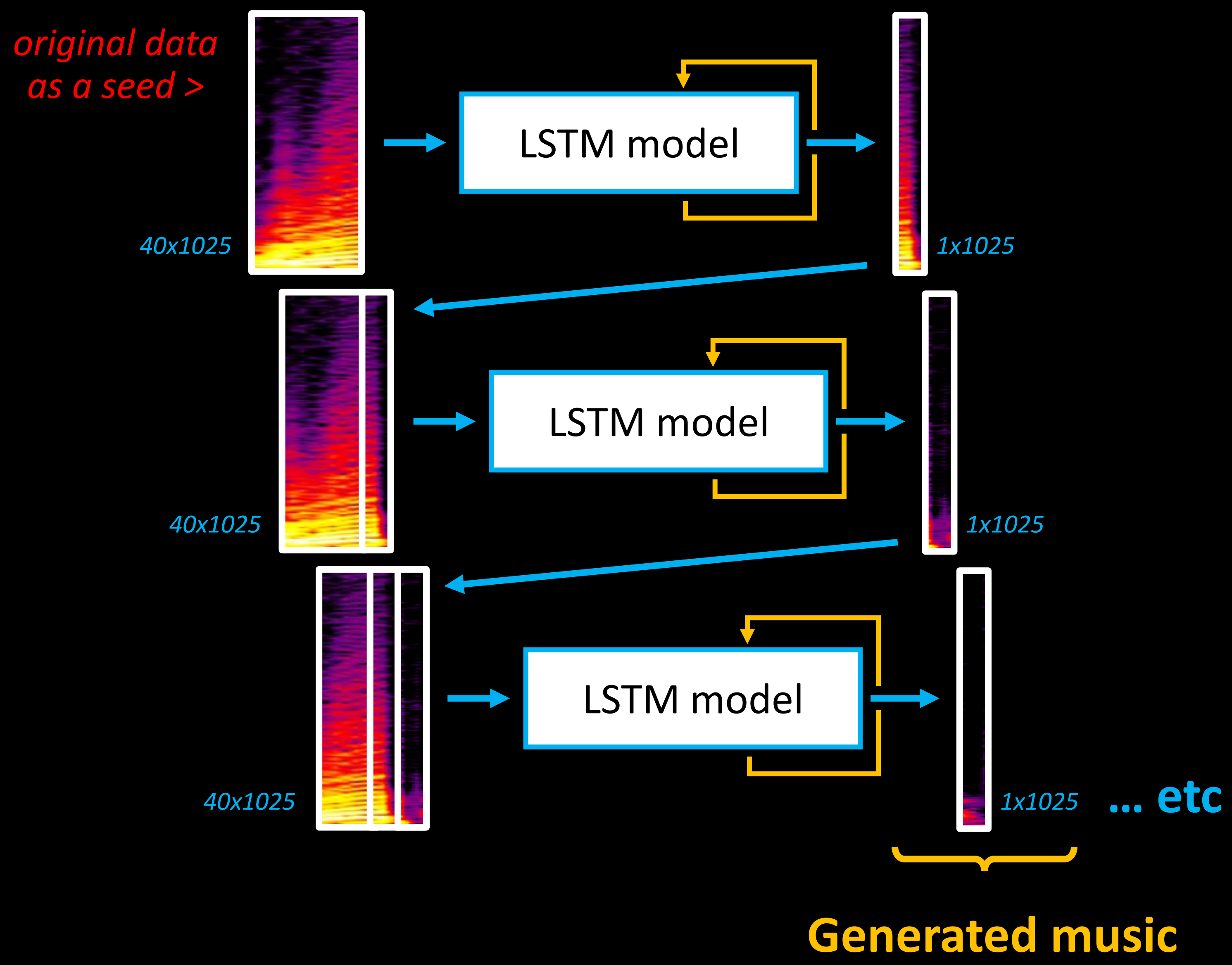
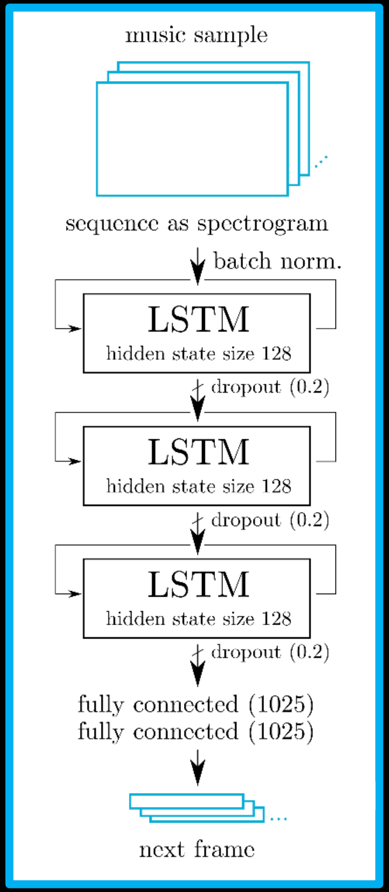


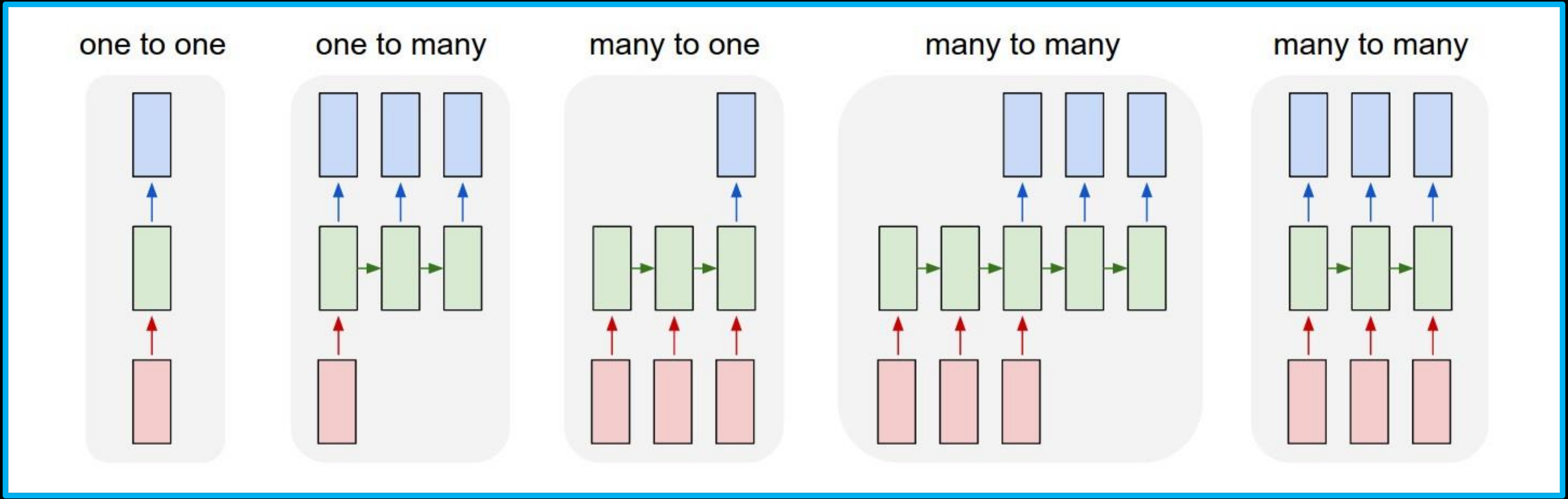
# Using a trained LSTM model:




- Check the **generated music sample**: ml-jazz-meanderings-ml-generated-sounds-1

# Types of models and data schemes



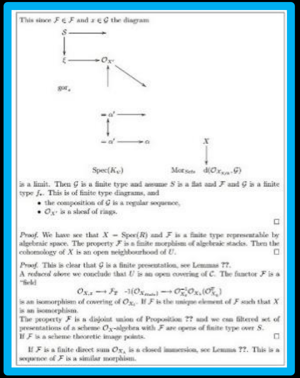

- The movement to the right on this illustration means **moving one timestep further** (next sample in the sequence)

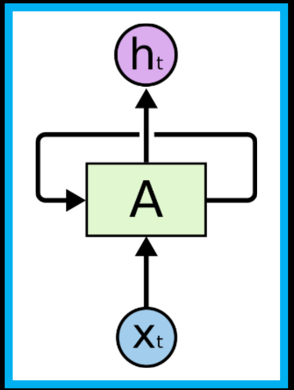
Illustration: [blog]

# Links and additional readings:

- **Bonus readings:**
  - **Andrej Karpathy blog** “The Unreasonable Effectiveness of Recurrent Neural Networks” – rnn-effectiveness
    - Citation: *There’s something magical about Recurrent Neural Networks (RNNs). … This post is about sharing some of that magic with you. We’ll train RNNs to generate text character by character and ponder the question “how is that even possible?”*
  - **Blog** “Understanding LSTM Networks” - Understanding-LSTMs

- **Code samples:**
  - **WordRNN**: Working repository for training and using a multilayer RNN and LSTM models – word-rnn-tensorflow
  - **Text analysis**: Gensim library examples



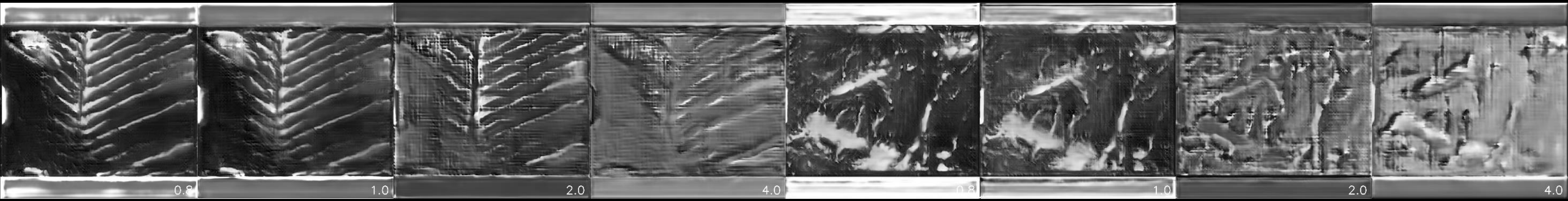


# Practicum live session

- This week's live session will be organized as a **Q&A session** about all the material that we went through in the class
- **Assessment requirements** details – on our moodle page

# Exploring Machine Intelligence

## Week 7, Sequential Modelling




# Final Exam Q&A

~ Vítek Růžička

# Weeks overview

- **I.** Intro & Motivation
- **II.** Fully Connected Neural Networks
- **III.** Convolutional Neural Networks
- **IV.** Interactive ML
- **V.** AutoEncoders and GANs
- **VI.** Domain2domain (pix2pix), Style Transfer, Deep Dream
- **VII.** Sequential models

**Element 1: Online testing:** Moodle quizzes with practical and theoretical questions. (50%) **[Finished!]**

**Element 2: Final examination:** Online quiz with 20 multiple choice questions and 3 open ended questions (expect short essay answers). (50%) **[opens at 12.06.]**

- Following slides include some **example topics and questions** that may appear in the exam (*PS: these are on purpose hard; in the exam they will be easier*).

# I. Intro & Motivation

- **Linear regression**

# II. Fully Connected Neural Networks

- **Neuron parameters**
- **Fully Connected Neural Network**
  - Connectivity of a neuron
- **Error between prediction and label**

# III. Convolutional Neural Networks

- **Model overfitting**
- **Convolution**
  - As a filter
  - Parameters
  - Locality
- **What allows layers of CNN to specialize?**
- **Describe how we can think about an existing models as having the feature extractor and classifier section?**

# V. AutoEncoders and GANs

- **Describe AutoEncoder as an identity operation learning**
- **Describe GAN as a two-player game**
  - What is the purpose of Generator?
  - What is the purpose of Discriminator?
- **Differences between default versions of AE and GAN**
  - Encoding-ability
  - Loss function
- **Progressive Growing GAN details**
- **Visual attribute vectors**
- **Interaction with GANs / AEs**

# VI. pix2pix, style transfer, deep dream

- **Describe pix2pix as a translation**
- **Describe style transfer as a content and style separation**
  - How do we edit the input image?
- **Describe the deep dream technique**
  - What are we trying to maximize?

# VII. Sequential models

- **Describe what do we want from sequential models?**
- **Describe text vectorization (encoding)**
- **Describe music vectorization (encoding)**

# The end