

# CS 523: Multimedia Systems

Angus Forbes

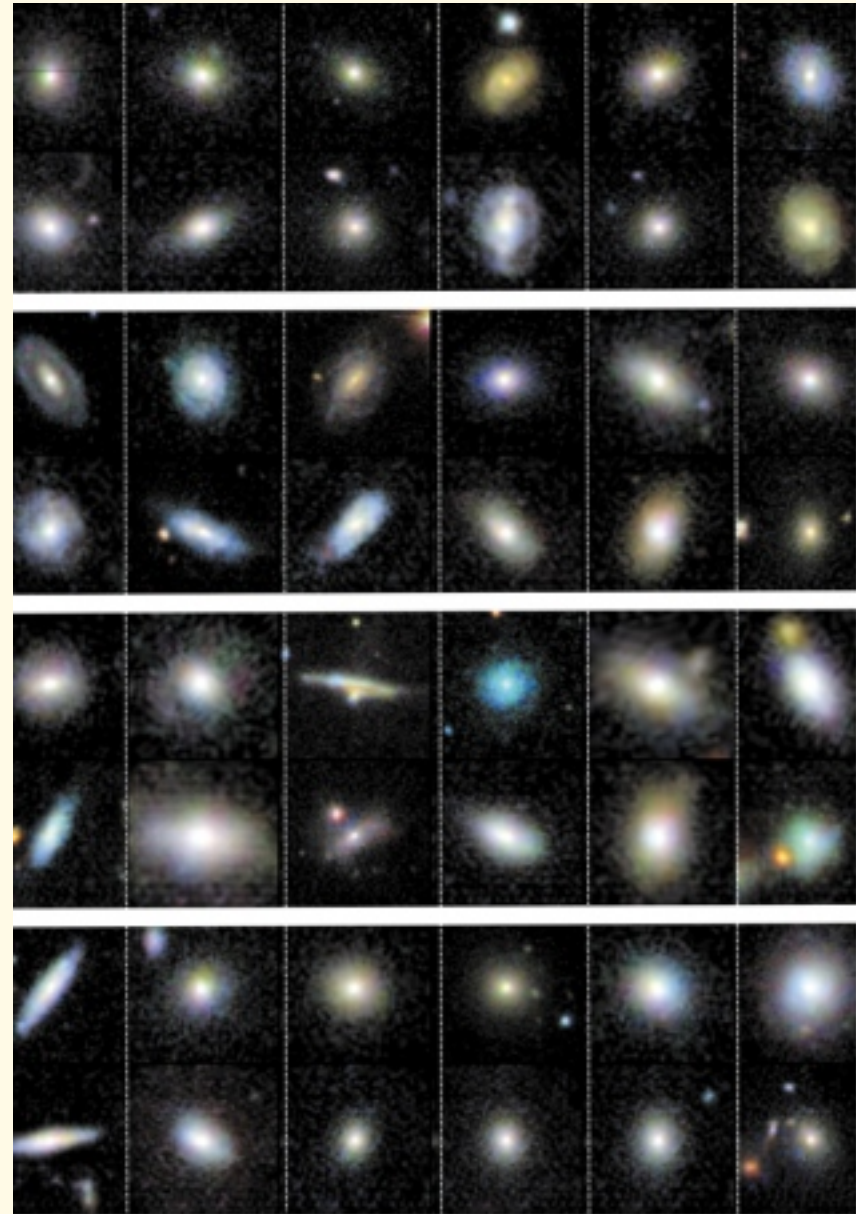
[creativecommons.evl.uic.edu/courses/cs523](http://creativecommons.evl.uic.edu/courses/cs523)

# Today

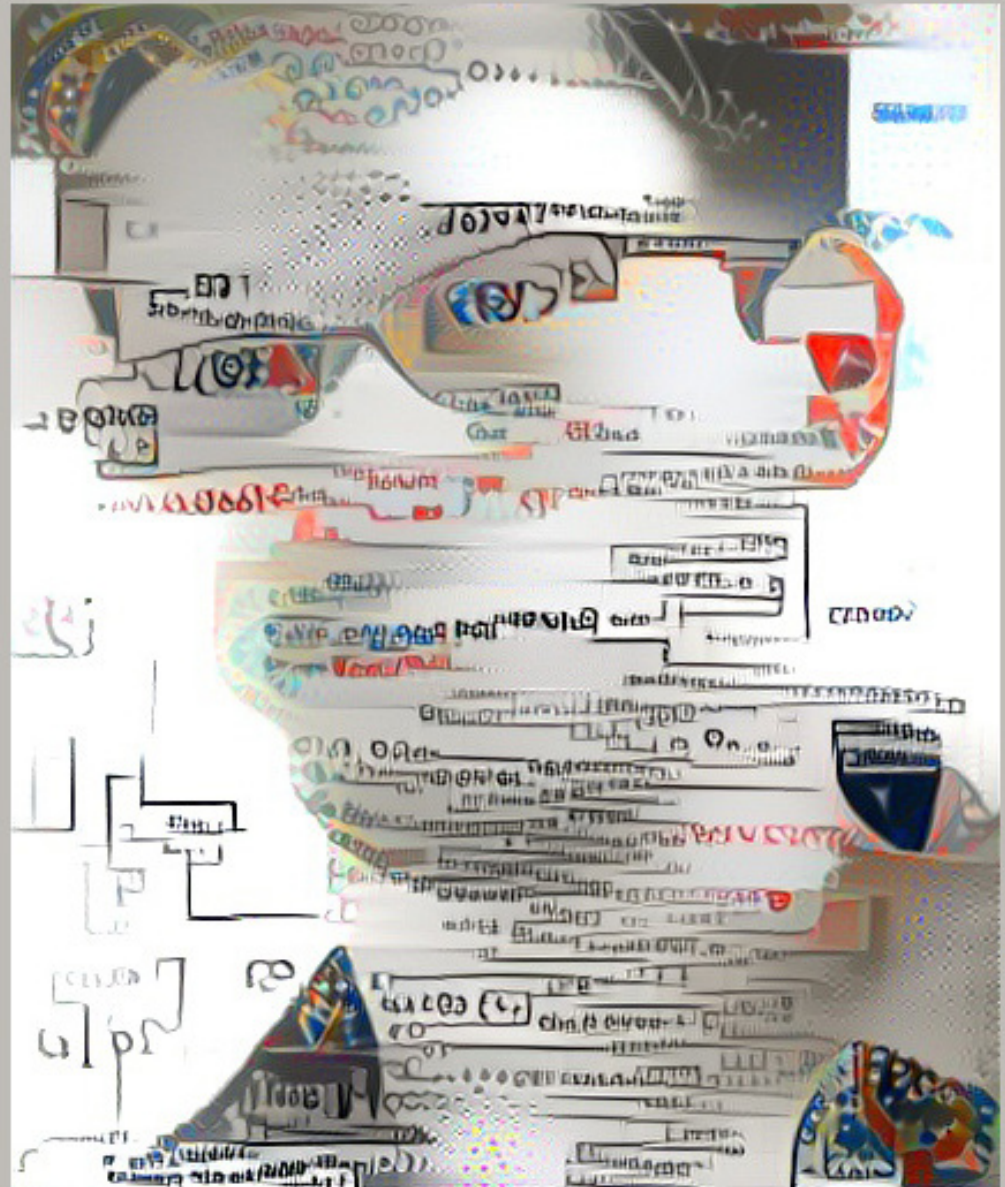
- Recurrent Neural Networks
- Project 1 Demos + Code

**“The Square Kilometre Array (SKA), a radio-astronomy observatory to be built in South Africa and Australia, will produce such vast amounts of data that its images will need to be compressed into low-noise but patchy data. Generative AI models will help to reconstruct and fill in blank parts of those data, producing the images of the sky that astronomers will examine.”**

**<http://www.nature.com/news/astronomers-explore-uses-for-ai-generated-images-1.21398>**



<http://www.plummerfernandez.com/snowden-ppt>



# Recurrent Neural Networks (RNNs)

“The core reason that recurrent nets are more exciting is that they allow us to operate over sequences of vectors: Sequences in the input, the output, or, in the most general case, both.” -Andrej Karpathy

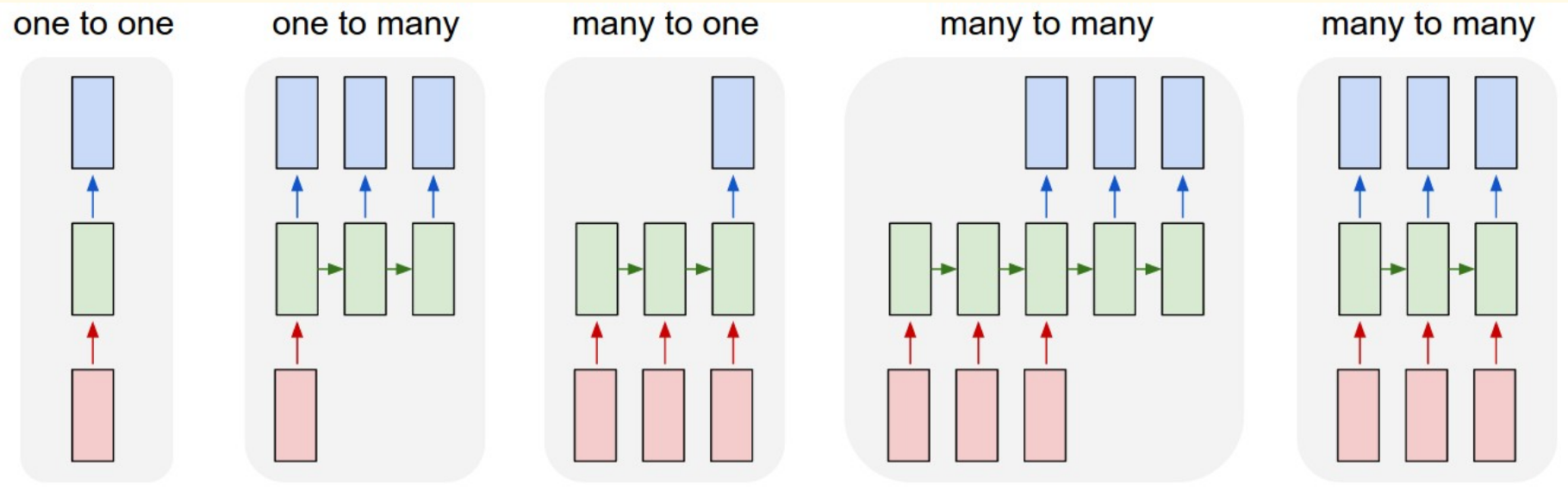
## Sequences

Time series data, streaming data, videos, audio, text, speech, translation, etc., and also things that we don't think of as sequences, like a static image that you look at over a period of time.

# Recurrent Neural Networks (RNNs)

RNNs contain loops that represent a kind of “memory” about what’s been present previously in the sequences of data.

A memory persists due to the fact that the values of the hidden layers at each timestep are based on an operation that involves both the inputs for the *current* timestep and the outputs of the *previous* hidden layer.



(1) Vanilla mode of processing without RNN, from fixed-sized input to fixed-sized output (e.g. image classification).

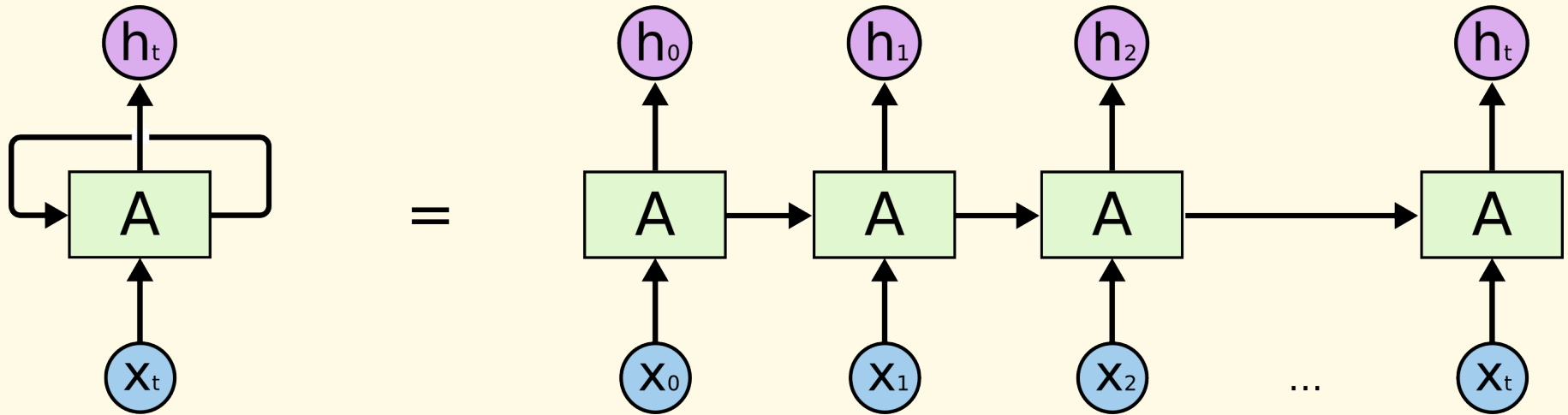
(2) Sequence output (e.g. image captioning takes an image and outputs a sentence of words).

(3) Sequence input (e.g. sentiment analysis where a given sentence is classified as expressing positive or negative sentiment).

(4) Sequence input and sequence output (e.g. Machine Translation: an RNN reads a sentence in English and then outputs a sentence in French).

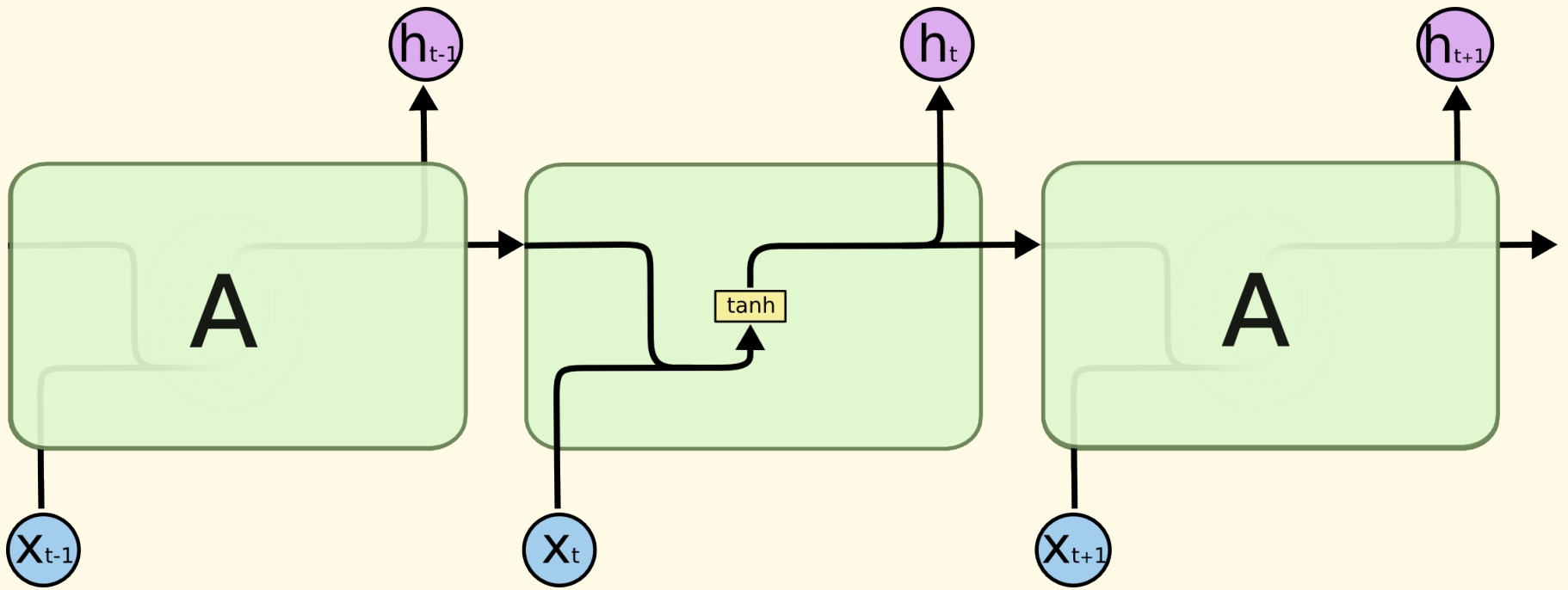
(5) Synced sequence input and output (e.g. video classification where we wish to label each frame of the video).

The recurrent transformation (green) is fixed and can be applied as many times as we like.



Chris Olah, "Understanding LSTM Networks"





# Memory in RNNs

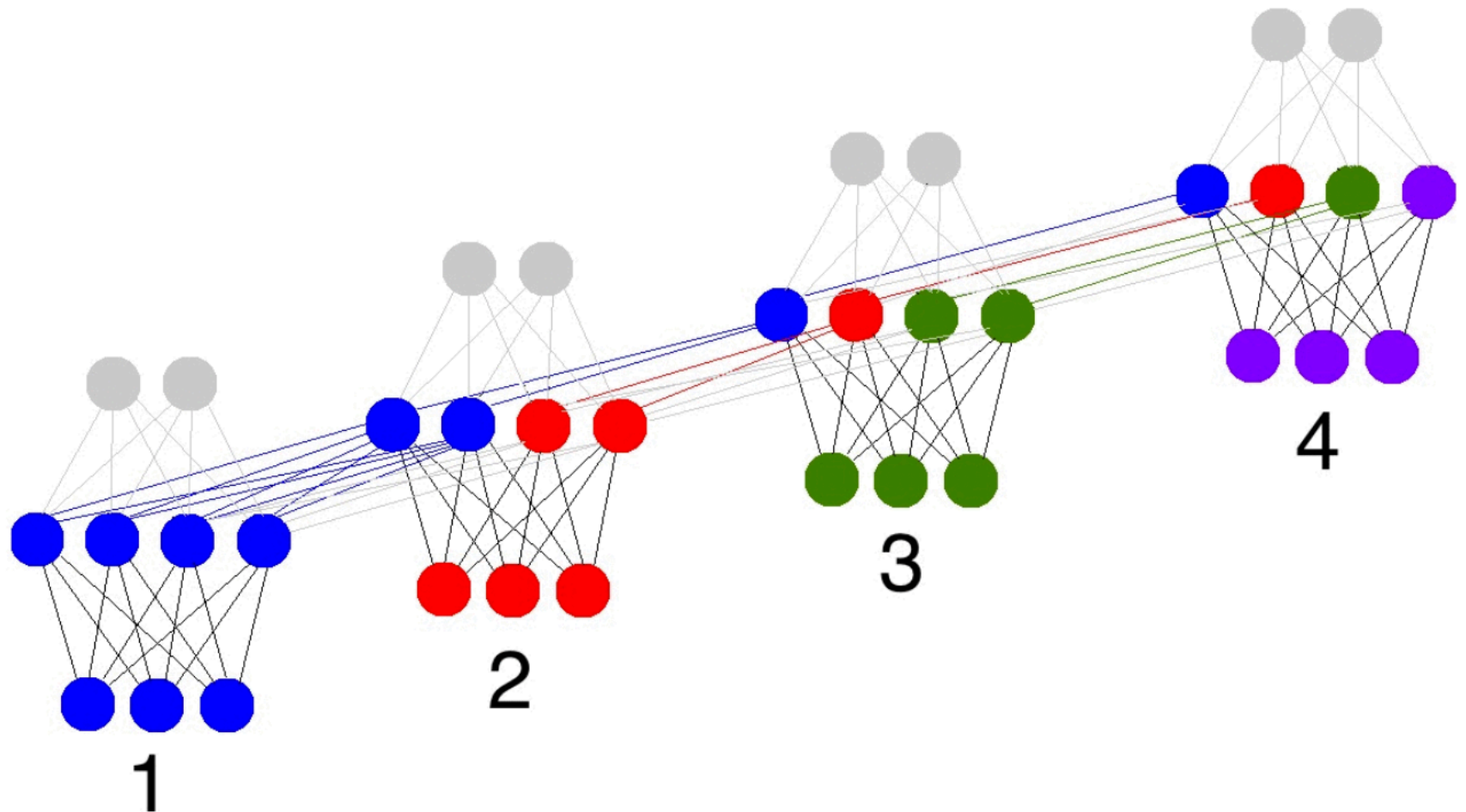
## Remembering the immediate past:

(input + empty_input)	-> hidden	-> output
(input + prev_input)	-> hidden	-> output
(input + prev_input)	-> hidden	-> output
(input + prev_input)	-> hidden	-> output

## Remembering the distant past:

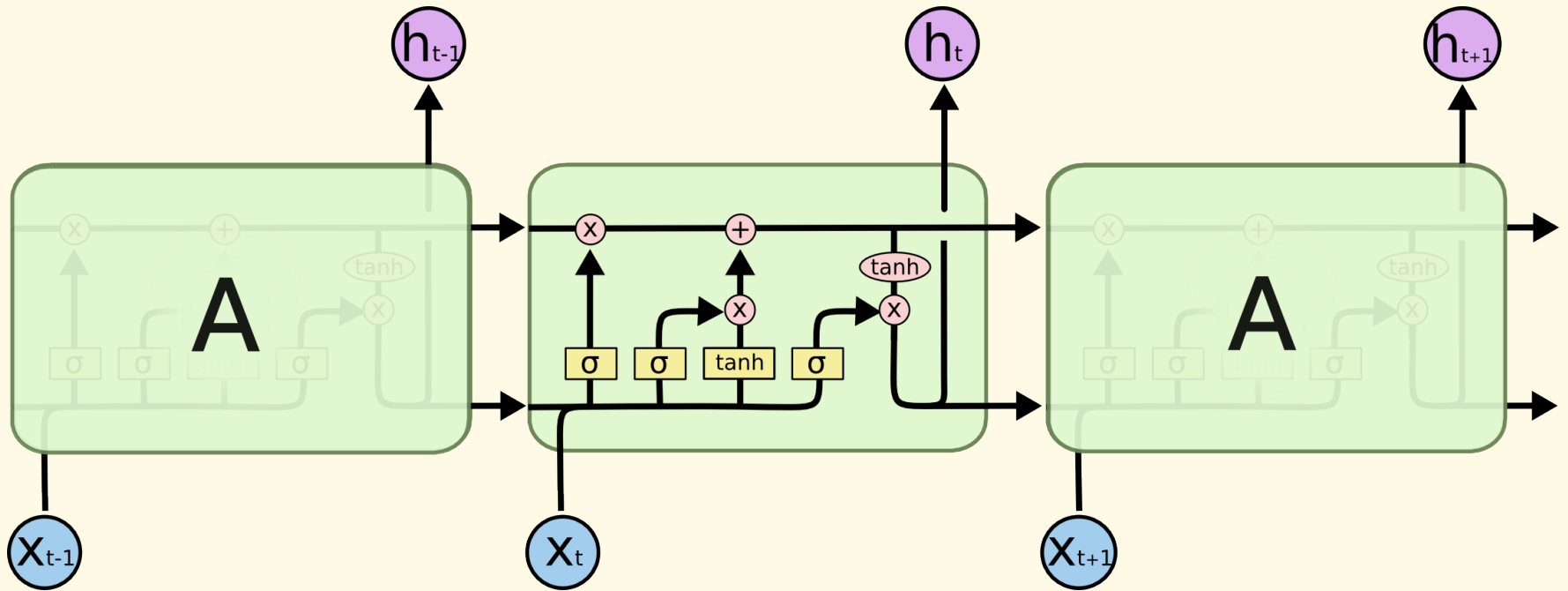
(input + empty_hidden)	-> hidden	-> output
(input + prev_hidden)	-> hidden	-> output
(input + prev_hidden)	-> hidden	-> output
(input + prev_hidden)	-> hidden	-> output

*RNNs learn what to remember.*



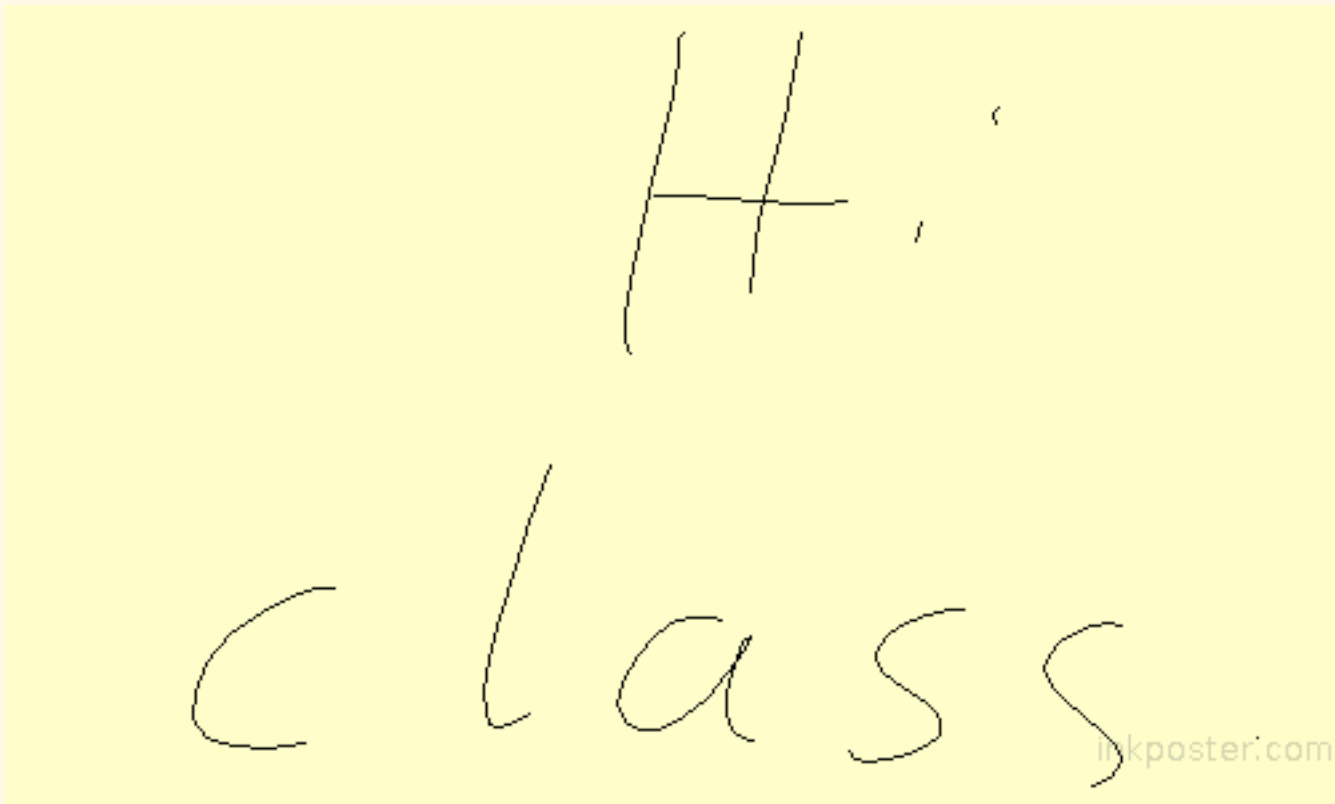
Andrew Trask, "Anyone Can Learn To Code an LSTM-RNN"

# Long Short Term Memory

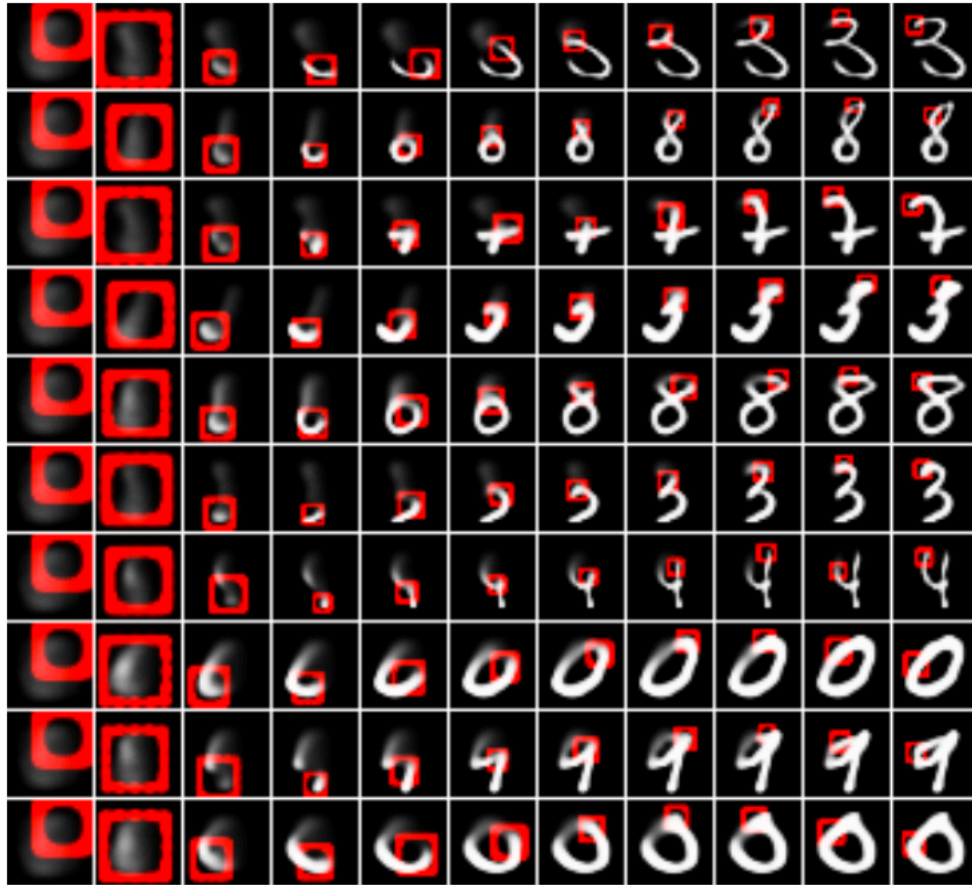


# text to handwriting

<http://www.inkposter.com/>



# mimicking pen strokes + drawing



Time →

[https://  
www.youtube.com/  
watch?  
v=Zt-7MI9eKEo](https://www.youtube.com/watch?v=Zt-7MI9eKEo)

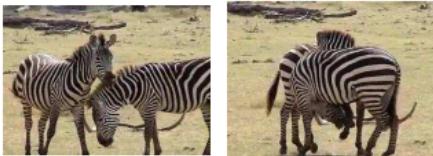
# video to text snippets

Venugopalan et al., ICCV 2015

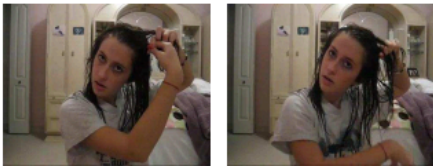
## Correct descriptions.



S2VT: A man is doing stunts on his bike.



S2VT: A herd of zebras are walking in a field.



S2VT: A young woman is doing her hair.

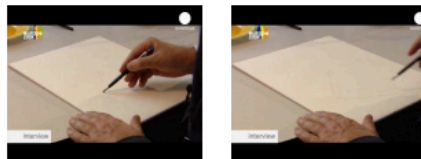


S2VT: A man is shooting a gun at a target.

## Relevant but incorrect descriptions.



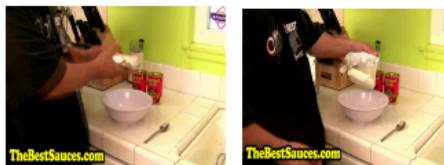
S2VT: A small bus is running into a building.



S2VT: A man is cutting a piece of a pair of a paper.

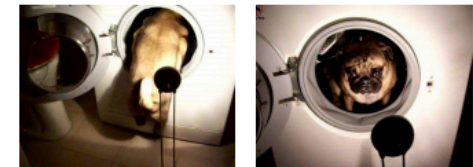


S2VT: A cat is trying to get a small board.



S2VT: A man is spreading butter on a tortilla.

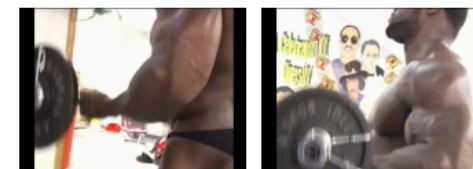
## Irrelevant descriptions.



S2VT: A man is pouring liquid in a pan.



S2VT: A polar bear is walking on a hill.



S2VT: A man is doing a pencil.

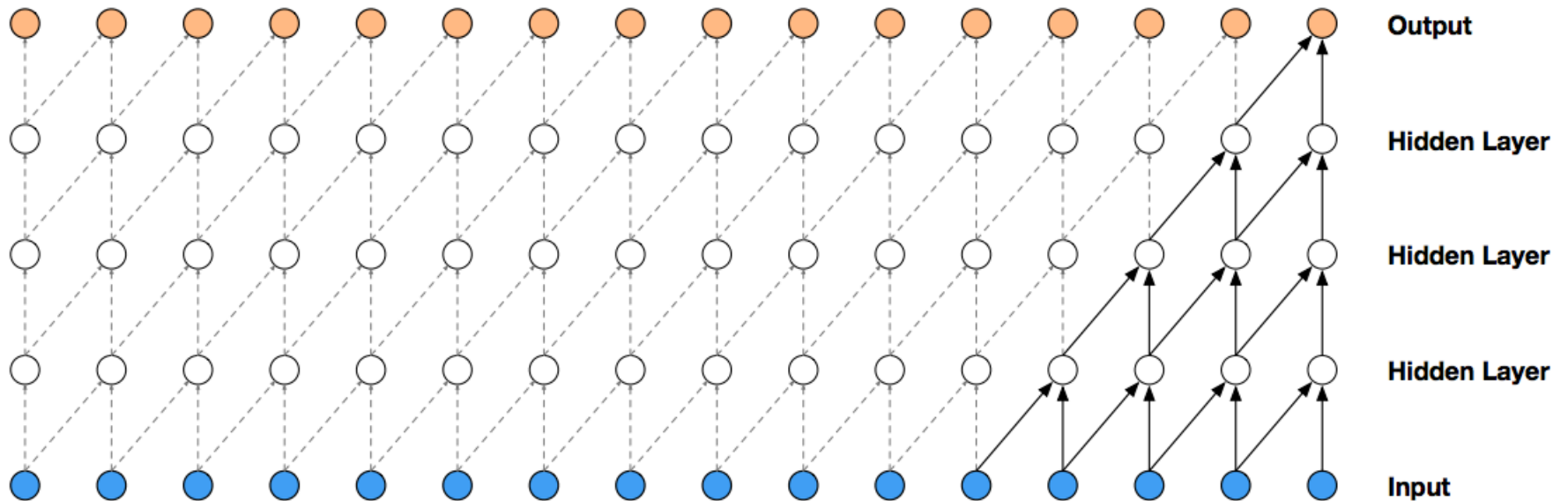


S2VT: A black clip to walking through a path.

# text to speech

WaveNet - generating realistic audio samples

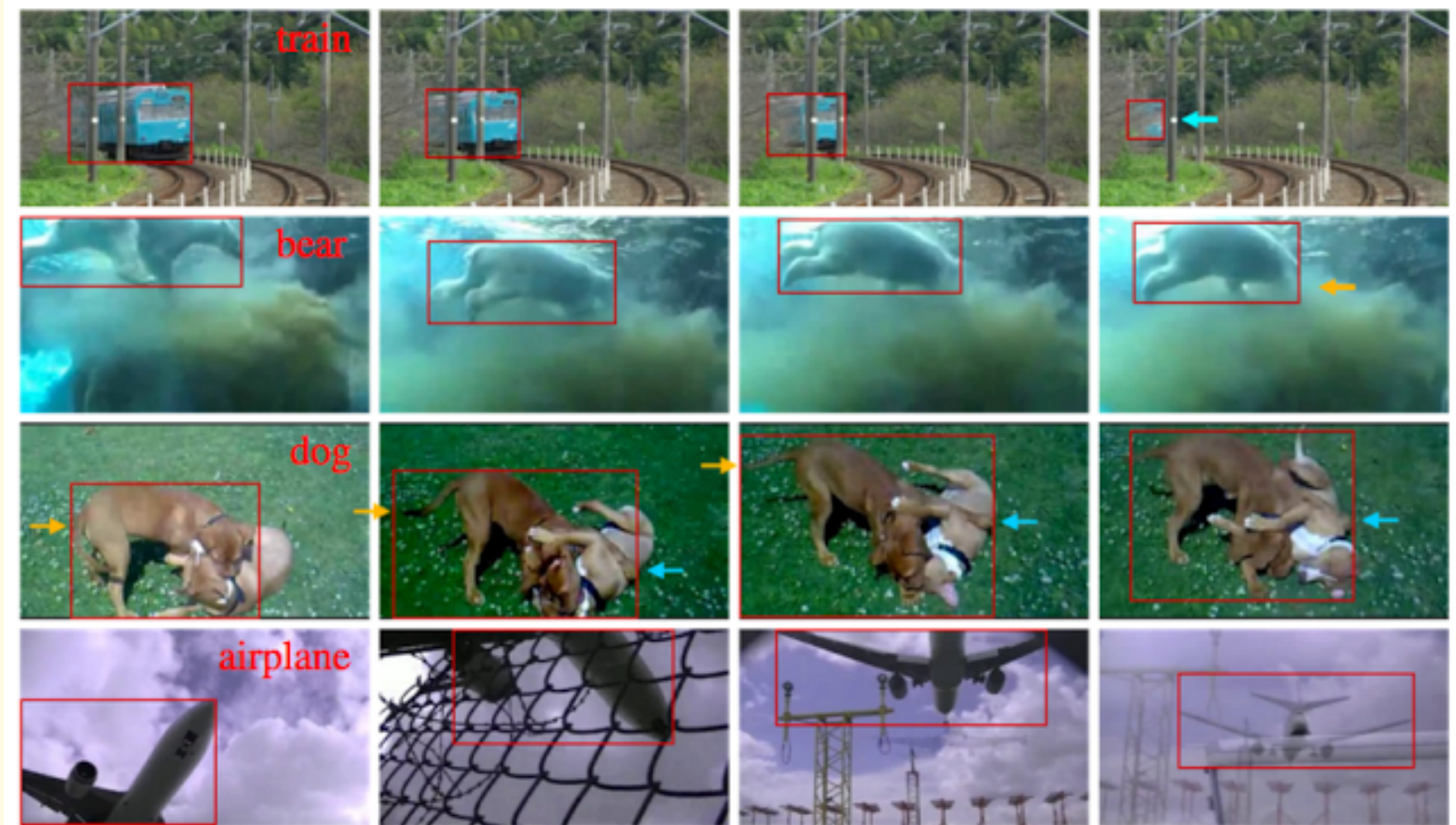
<https://deepmind.com/blog/wavenet-generative-model-raw-audio/>





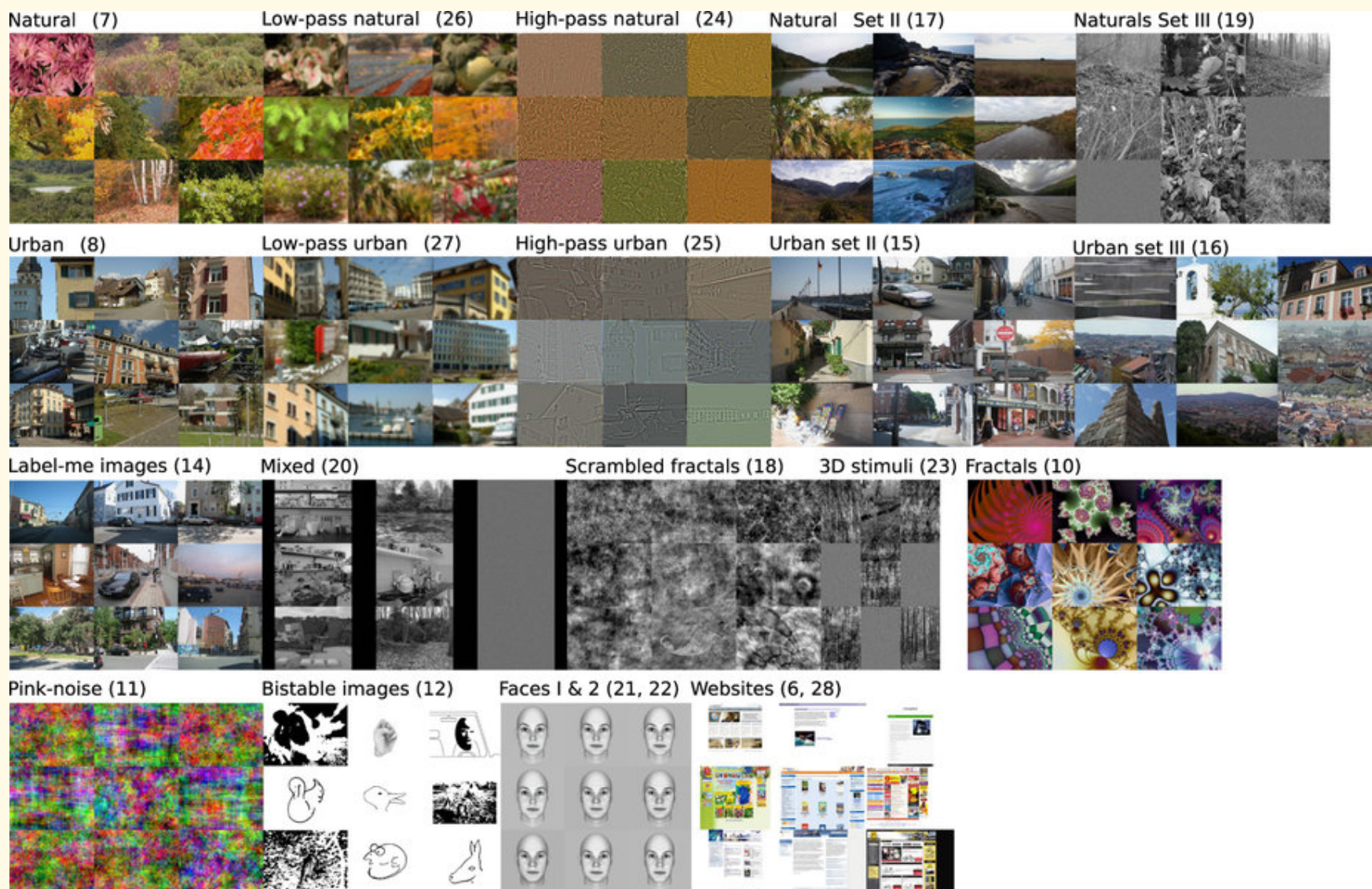
Google's just released YouTube sequence data set...

<https://research.googleblog.com/2017/02/advancing-research-on-video.html>



# "An extensive dataset of eye movements during viewing of complex images"

<http://www.nature.com/articles/sdata2016126>



# RNN – Shakespeare – 12000

That she dire thou should this  
ten tale,  
Sistles all overtienced about off  
the town;  
To fainting but sue, I do awfeld;  
I will church.

ROMEO:  
Trumpet the substerety and see,  
I wind-quench to skeet of this a  
daughter.

Citizens:  
Which I shall not hear all to be  
ten receive,  
Myself Mantages you all then  
drouces, he excelse, as we  
should  
those done to York at  
The emptying to be mine own  
jeatures:  
We do of my rescurent to would  
enbused: and  
committy brows too, in a post

<https://github.com/karpathy/char-rnn>

<https://github.com/sherjilozair/char-rnn-tensorflow>

# RNN – Emily Dickinson - 0

,H6r?o4NjsCdC!CPi

m'U.vCQbSCBj. J4luJ]pJVJJv

4CMiJtRRJCQ P'I

p4.f3

Hlv0 9oc[biCC.ly4Er

6l[skB5C.MJxpvHMJBZNkiC!Cxl35bsR[0 JsvikJrCUkkUC]Jzo'8'oPusl ev

Rib[ubJBImZBo84

Jo6CB.bs

MmP4Ps6HkPWrmNvumm0J?jb.bYkZvsCWpMY ;[r.jvpdb4;1pibPLuI0

dUCd;S6QRp[BmP4g.H6l

Jg 0

8;HJVvSW8rkMrxss Hi4;jvC'so

# RNN – Emily Dickinson – 500

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And Snive Eald knent --  
Dwow and Sor --  
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'Then is Mide.

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The Cumaun a jeculd --  
Ansolk priate Mecby  
That all Or Rase --  
linchy Cualiot --  
Bet lind the Dooige  
The Mashest tomares --

Dotnent of Mone of laM  
The Nos erencten  
J0

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arlopinestisumlear

Yeethade Puvéd lit Ather  
Tang. Ther Cpantties fralres  
's0ow -- Daddy or fean!

# RNN – Emily Dickinson – 1500

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--  
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Cexcendnay --  
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Of the Buigled -- but your by --  
The Chopned a Veious

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And they daysur siffink --  
But Ond there umparese --  
The Jost bidning it --

863

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Lay, resterbried frupmerin --  
And excace ashom

# RNN – Emily Dickinson – 3000

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Or boun I Zots --  
And Seporated m5 So  
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And appantly old then  
"The We did siff gain yoors --  
itself --  
It speed it all for Heaven --  
We muddy all Gut, mown --

And who be?

A Conshal Scay to a Love  
Ancfeef too nearre -- the Long --

Of the Lay it for Arasp is faul  
A Wint Prone away  
This squirefred shated, a Codine  
--

Whing of Whries shill the  
Forgels --

Chird to Neaks --

What comp

# RNN – Emily Dickinson – 6000

383

Where upon they gain's recixed  
consume,  
And Could not day but a Grave  
--  
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along  
In a singerful Estaps --  
And readar's Ang his partual.

My Hoire tray Care of Closed  
Of Mine tonce the Windless  
Bundard,

Stop --

But left come

Oppose had little fame  
And amone vaul Laise Throw  
actiole

From lay bealves deation's  
super

For a disguise

For mery a fluvy age.

1272

'Tis is a Day loatice my Heay,  
Nor Nighty stealth stay



# RNN – Emily Dickinson – 9000

in a Hill to lie --  
I she finds, sug Would be  
Advanse without them be!

191

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Magigent, for Things all  
Anguiles of Requite  
Think for their One Crucles,  
Dead  
-- Compound I'm Gisdron  
But this Angelund From Mestys  
Pluoked itself an Apiniving --

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nothing  
To whose of red --

Not can see.

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# RNN – Emily Dickinson – 12000

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And whisime of Emember

Spirion "Yother Ear

While stwass will have chops of  
the Regarderty --

Whiteing herself the King --

1416

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1198

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the morn,

Legs Summer hid the Storings.

And care! that a Goalm to  
precight

Just Their a bring thee --

1528

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ways!

'Tis deptic grand, pety in cun --

# RNN – UIC Art Courses – 0

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3yhjNmmHqLm/tfOP)4-1/eHB P  
7NS-/yG  
w1y3vG1NyFg5Lqbi;  
Hj  
7ftfFe  
41GeNbVbGmcJp1yx;HxNt/  
VOOxS4DHsDiysgBJillb-  
SiPi)G/,/NxeHhq1D7LLheSv  
ts:LSL  
umr/i7:hxhb41PN-GbSN  
Gp7SmgxNs/14)7Sxc/LHpuGsG  
+yPR1LsSnmk,Ofb  
vpy4hGL,NDifLTNjf/xL/bLNG1x/

SbGVSD  
NyGVFOb;TEqPpjy1IH.tpNNmL;  
G0eN2a/11DfP-F P7;tL)xtq-N  
)Lvftcj  
/411f4SyRJeo/  
)t  
S  
qybaARrN0-ARVDLO/  
MpPfSN1b7b39/  
uudLGVuqjVPmt7;,bkgy1p/  
4Oey4g.fuq  
/ONtt+hSLe1Nb 1sVfF  
)SbxyH  
S/fsN.HfV1Sy;  
q3jbL

# RNN – UIC Art Courses – 1000

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# RNN – UIC Art Courses – 10000

one To. 4 hours.

Thenis to experimere and one Laboratory-Discussion on experiprents. Course Information: Previously listed as AD 8 342. May be repeated to a jamul arod a maximum of 12 hours. Extensive computer use required. Prerequisite(s): DES 452 or ART 272 and Sounmen. Prerequisite(s): To be preveotions of suctudior standing or above; or consent of immecis chidity dearl in one Laboratory.

ART 290. Topics in Agvectual and exte-ls. 4 hours.

Bess on on entrodution to regsteraty photography and

# RNN – UIC Art Courses – 30000

one to terinl prove standing or above; or consent cisteral theine, Photography. The to vartisiq express a vartiteo of resoatia. To be properly registered, students must enroll in one Lecture and one Laboratory.

ART 270. Topics in Screenings, students and later and indiracoss. Coursk on cresince II. 4 4o4. Extensive computer use required. Prerequisite(s): Sophomore standing or above; or consent of instructor. Class Schedule Information: To be properly registered, students must enroll in one Lecture.

# RNN – UIC Art Courses – 40000

**Class Schedule Information:** To be properly registered, students must enroll in ED0. May be repeated for a maximum of 8 hours. Extensive computer use required. Field trips required at a nominal fee. Prerequisite(s): lechoraphipls and sentractive vidaming in the fifmation, dial/ ad-or directions in contemporary pistered, students must enroll in one Lecture and one Laboratory.

**ART 362. Topics in Drawing I. 4 hours.**

**Apvient of the art foundation provents in conceptual-kivs**

# Project 2

- Generate novel output using an RNN
- Understand how to read and write Tensorflow code (lots of examples, tutorials online to learn from)
- Can work alone, or in groups of 2 or 3
- Will post project requirements on course webpage



# Next Week

- Project 2, ongoing
- Introduction to Generative Adversarial Nets (GANs)
- See syllabus for reading assignment