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COMP3055 Machine Learning

Topic 13 – Selected Topics on Deep Learning - RNN

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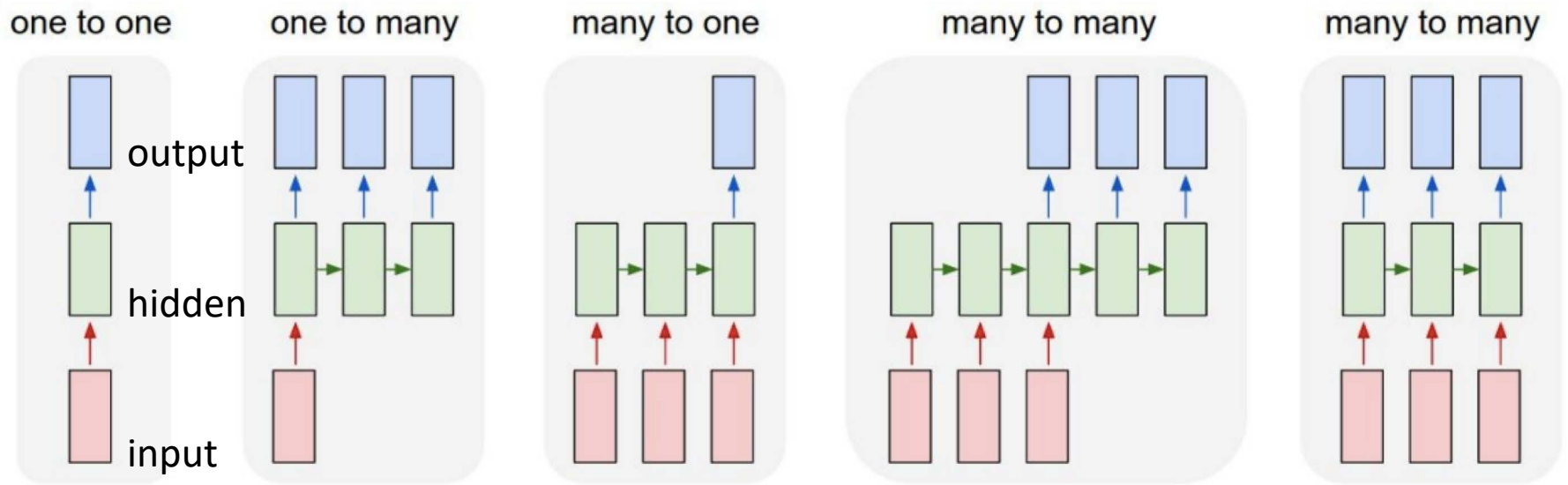
Motivation

- What kind of classification we see so far?
  - One to one mapping: one input (feature vector) to be classified into one output (class label).

- What if classification becomes more general?
  - One to many: one input maps to multiple output
  - Many to one: many input map to one output
  - Many to Many: many input map to many output

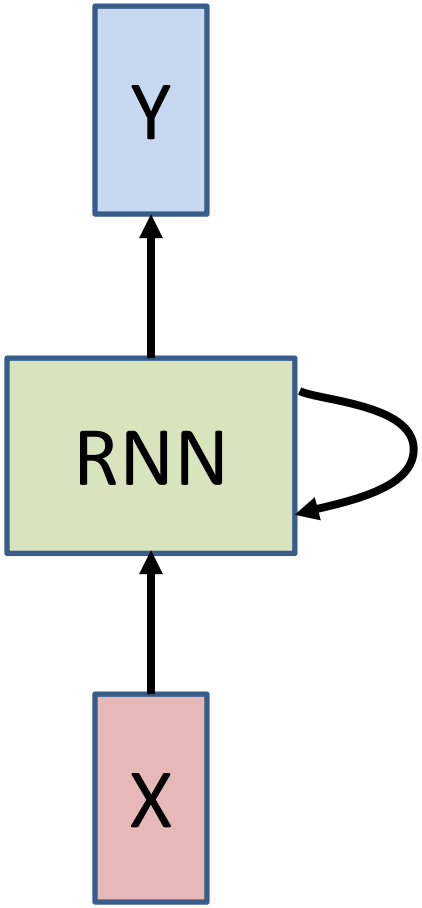
Recurrent Neural Network



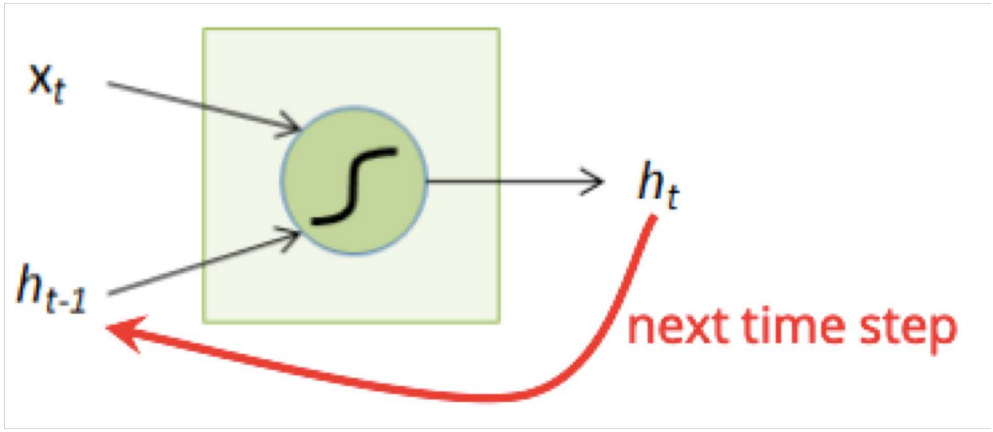
Examples of RNN applications

- One to many: image -> sequence of words (image captioning)
- Many to one: sequence of words -> sentiment (sentiment classification
- Many to many: sequence of words -> sequence of words (translation)

RNN – the Idea



Process the sequence of X over time t in recurrent neurons:

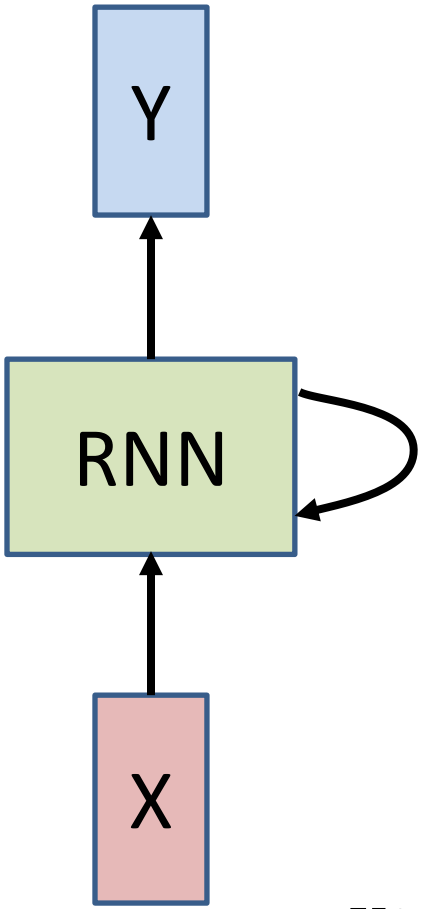


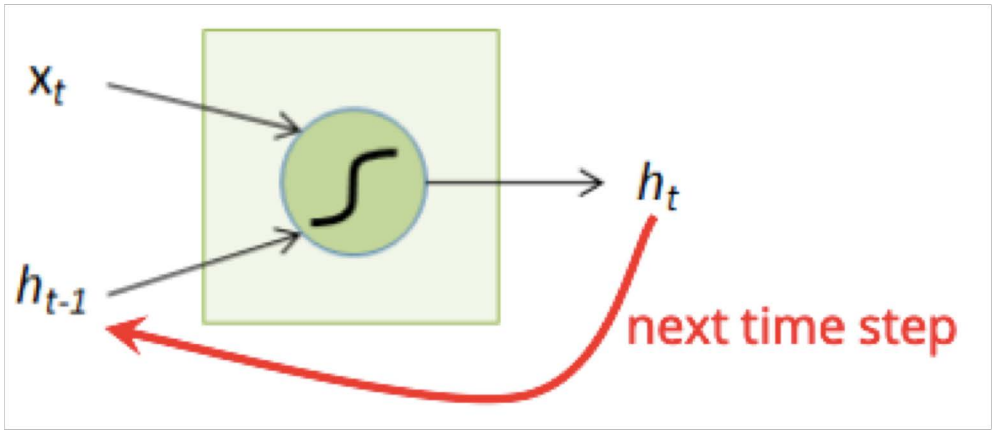
x_t: input at time t

h_t: hidden state at time t

h_{t-1}: hidden state at time t-1

RNN – the Idea



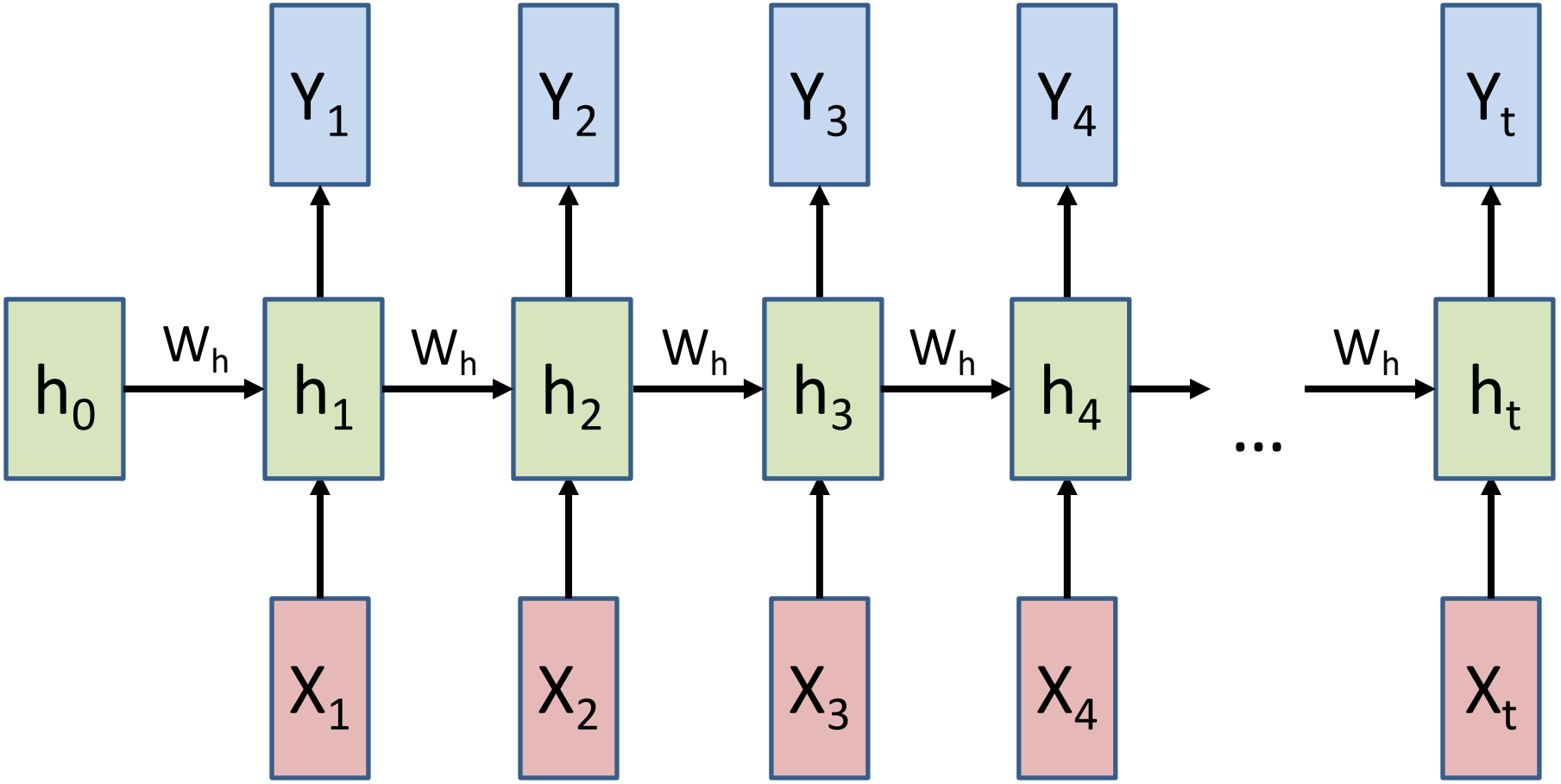


$$h_t = f(W_h h_{t-1} + W_x x_t)$$

Non-linearity: *tanh*

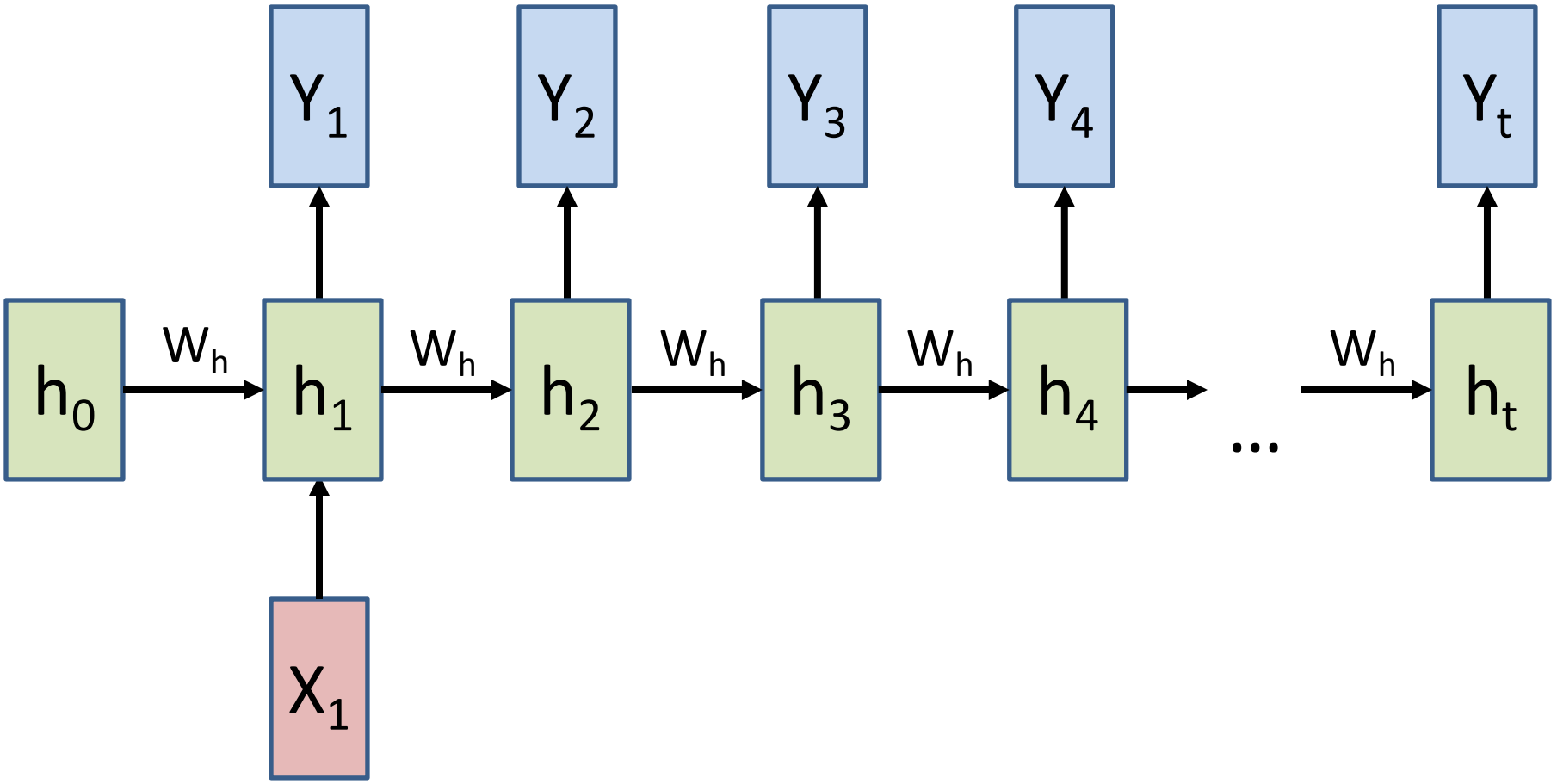
Y is computed similar to conventional neural network.

Unfolding RNN (Many to Many)



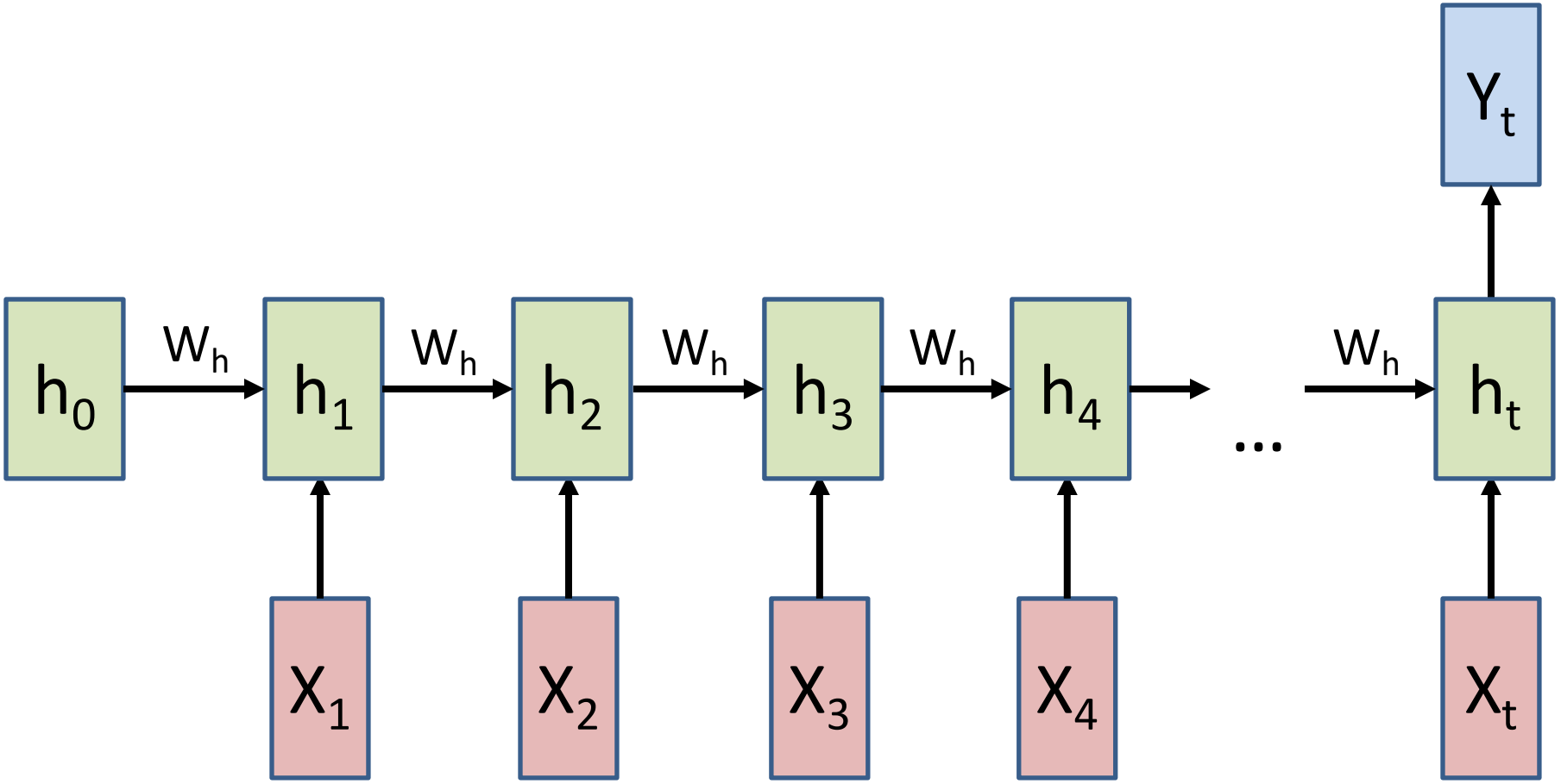
Same W_h is shared over time step.

Unfolding RNN (One to Many)



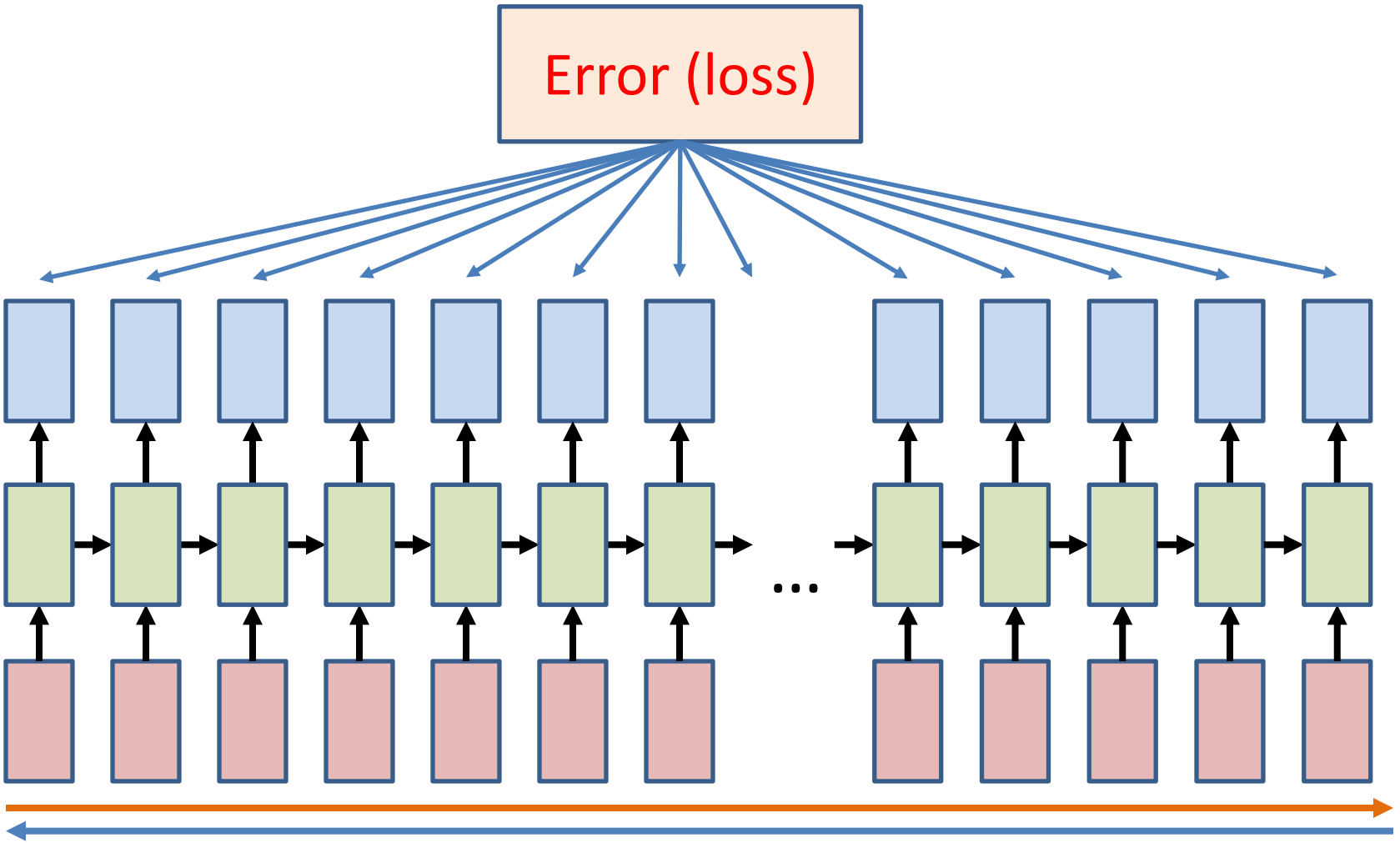
Same W_h is shared over time step.

Unfolding RNN (Many to One)



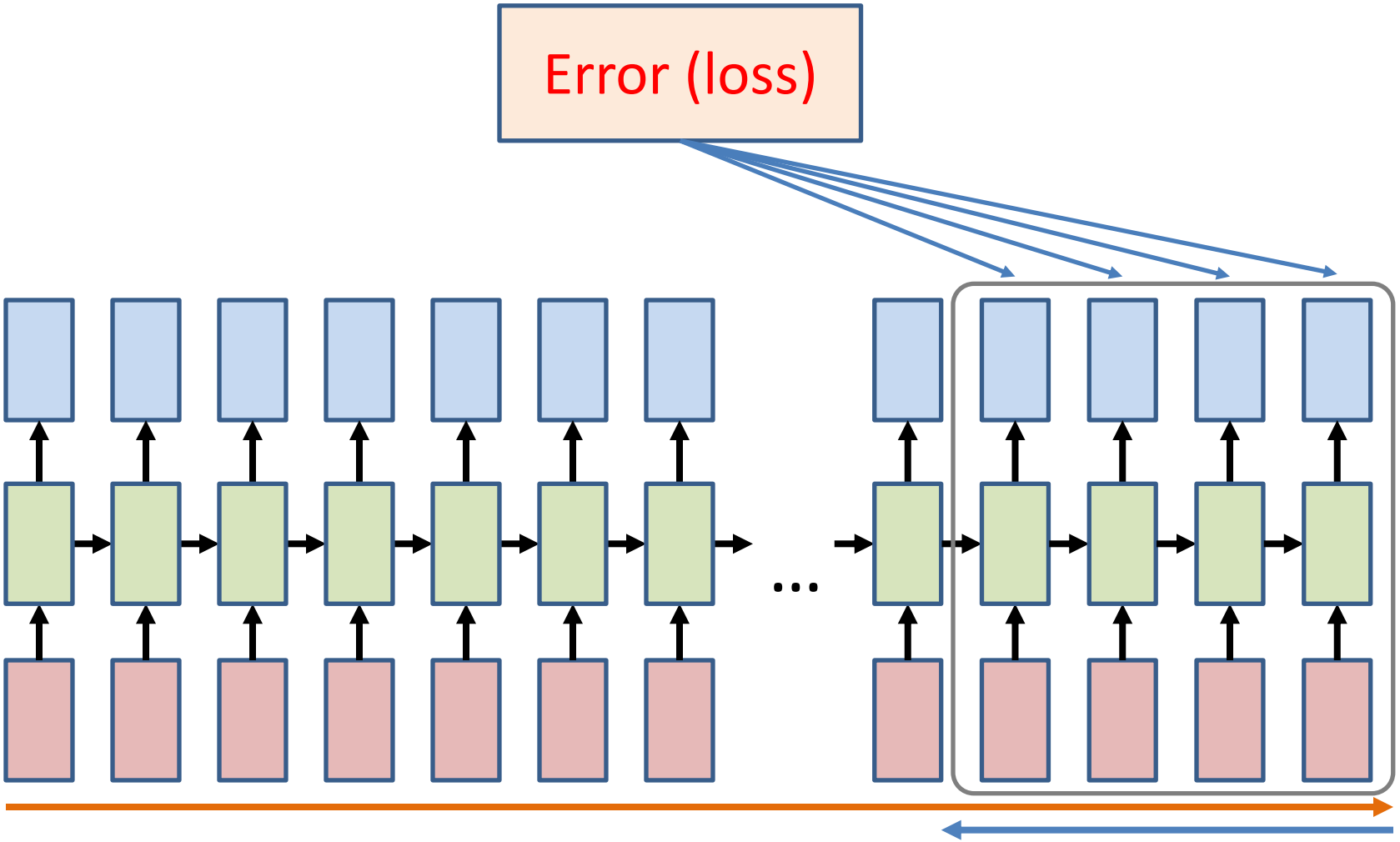
Same W_h is shared over time step.

Back Propagation Through Time



Error (loss) is computed forwardly through the whole sequence.
Gradients are computed backwardly through the whole sequence.

Truncated Back Propagation Through Time



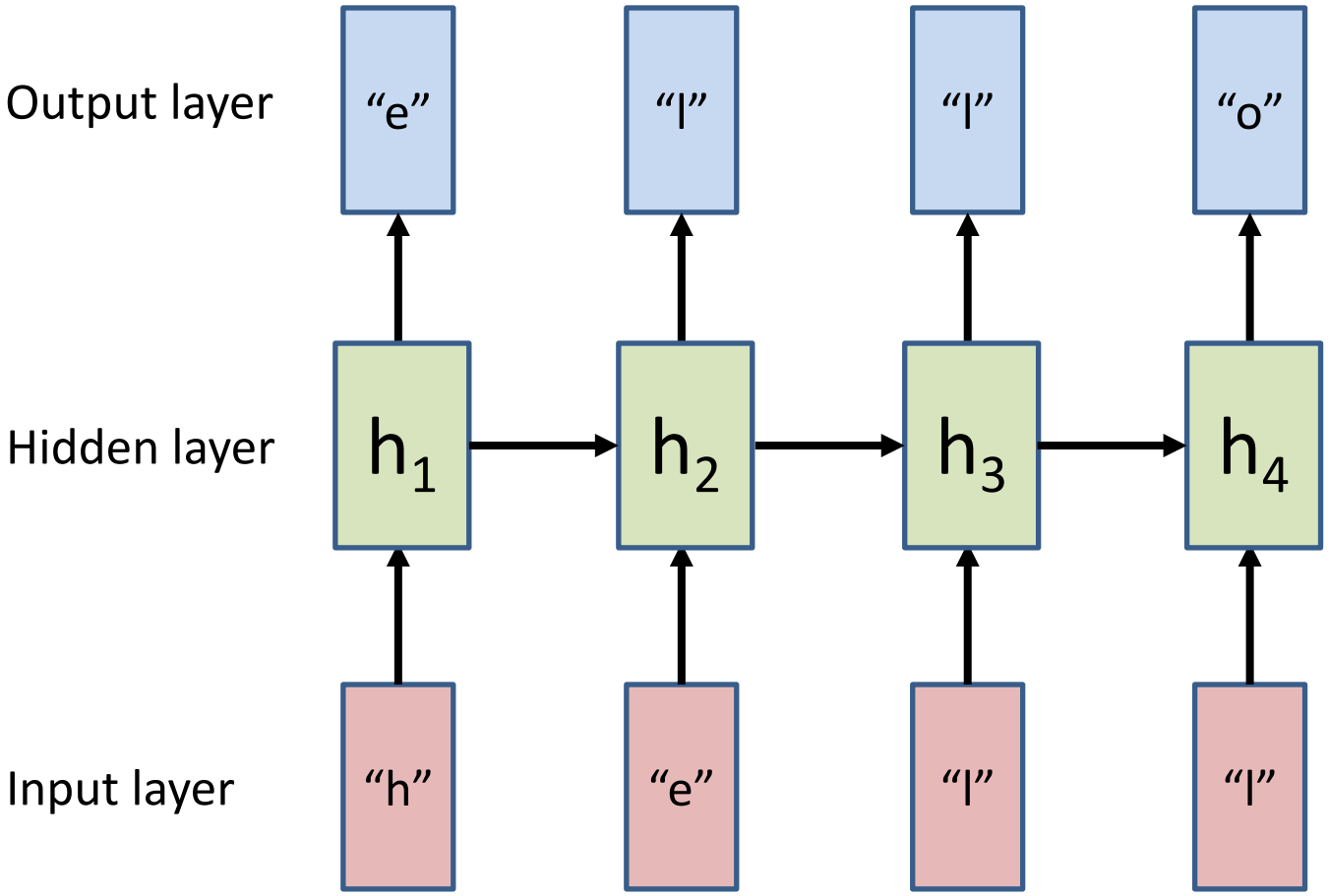
Forward computation is through the whole sequence.
Error and Gradients are computed through last few time step.

Toy Example

- Character level language model sampling
  - Suggest new characters based on seen characters.
  - Useful for spelling completion
- Vocabulary
  - [h, e, l, o]
- Training sample
  - “hello”

Toy Example - Training

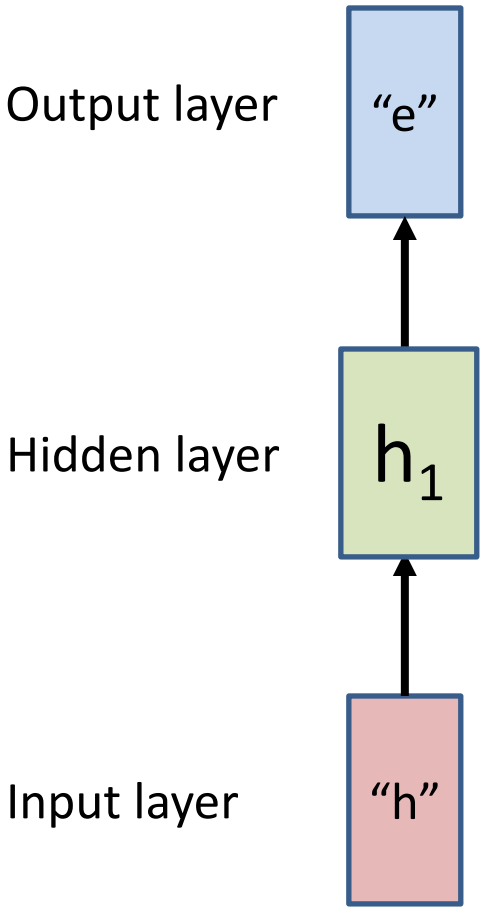
Training sample: "hello"



Use back propagation to compute all the Ws.

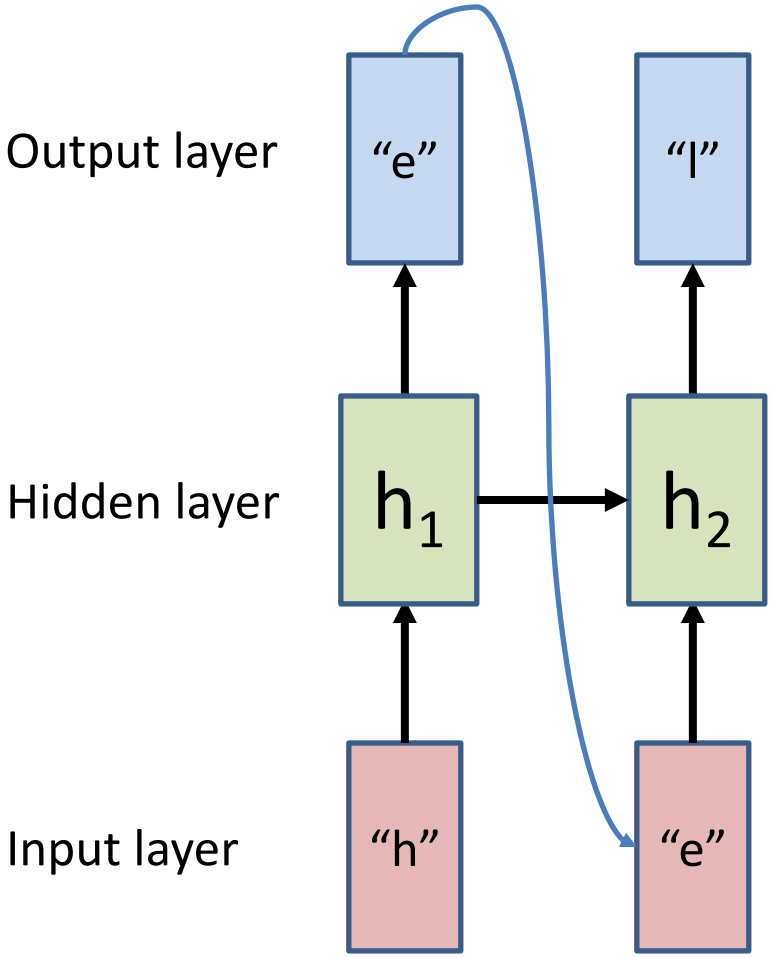
Toy Example - Testing

Testing sample: “hello”



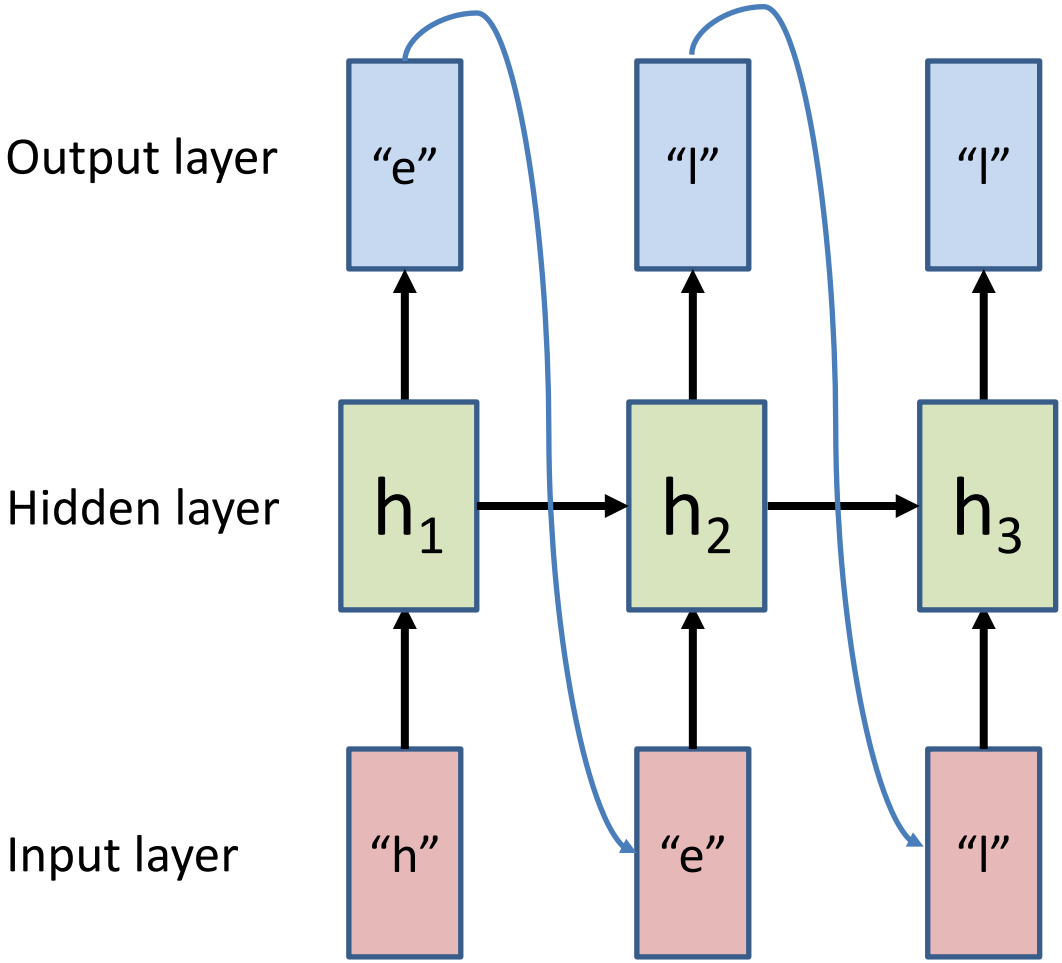
Toy Example - Testing

Testing sample: “hello”



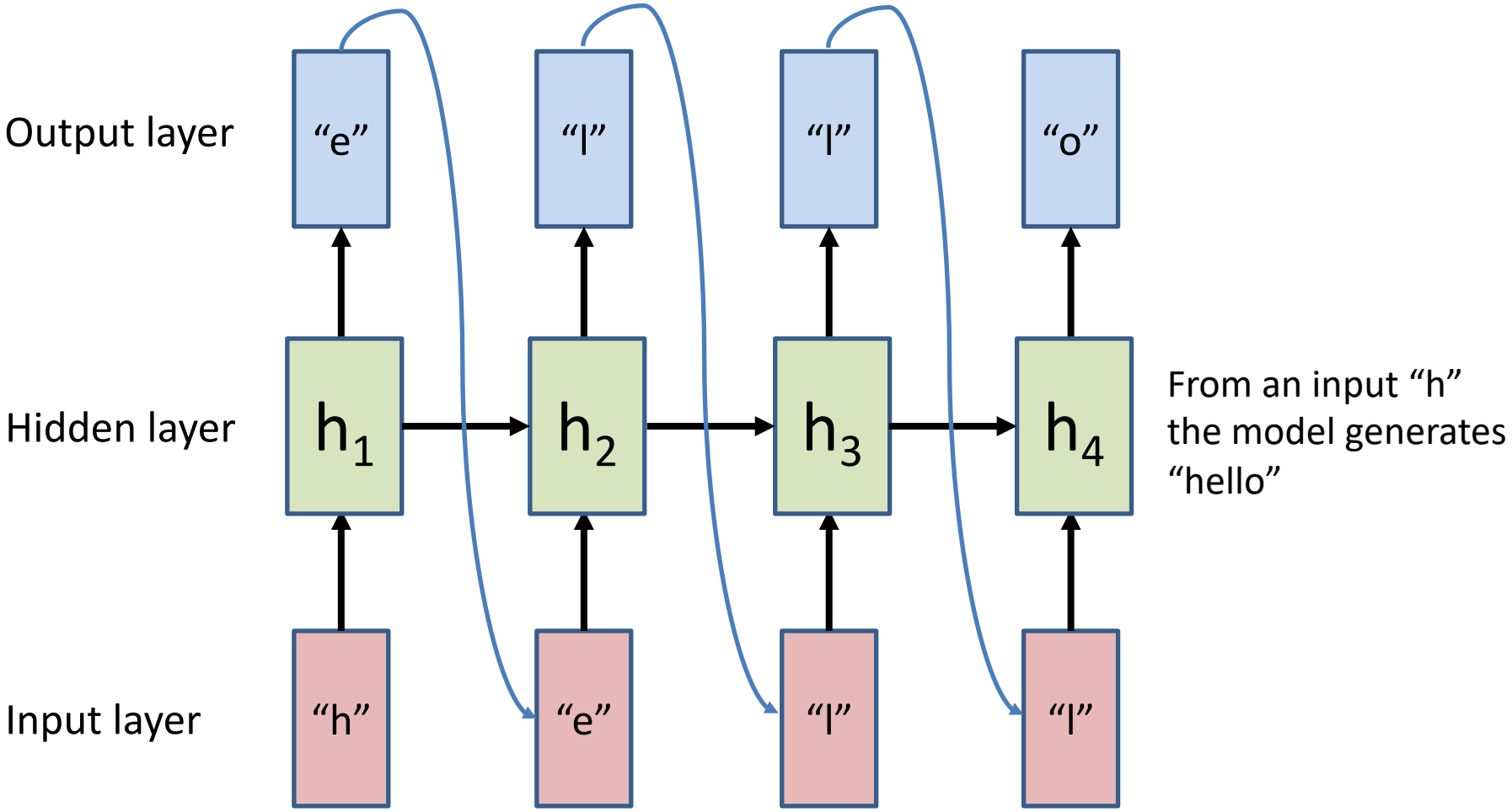
Toy Example - Testing

Testing sample: “hello”



Toy Example - Testing

Testing sample: “hello”



Application of RNN

Image captioning

- Generate caption for a given image
- Combine CNN and RNN

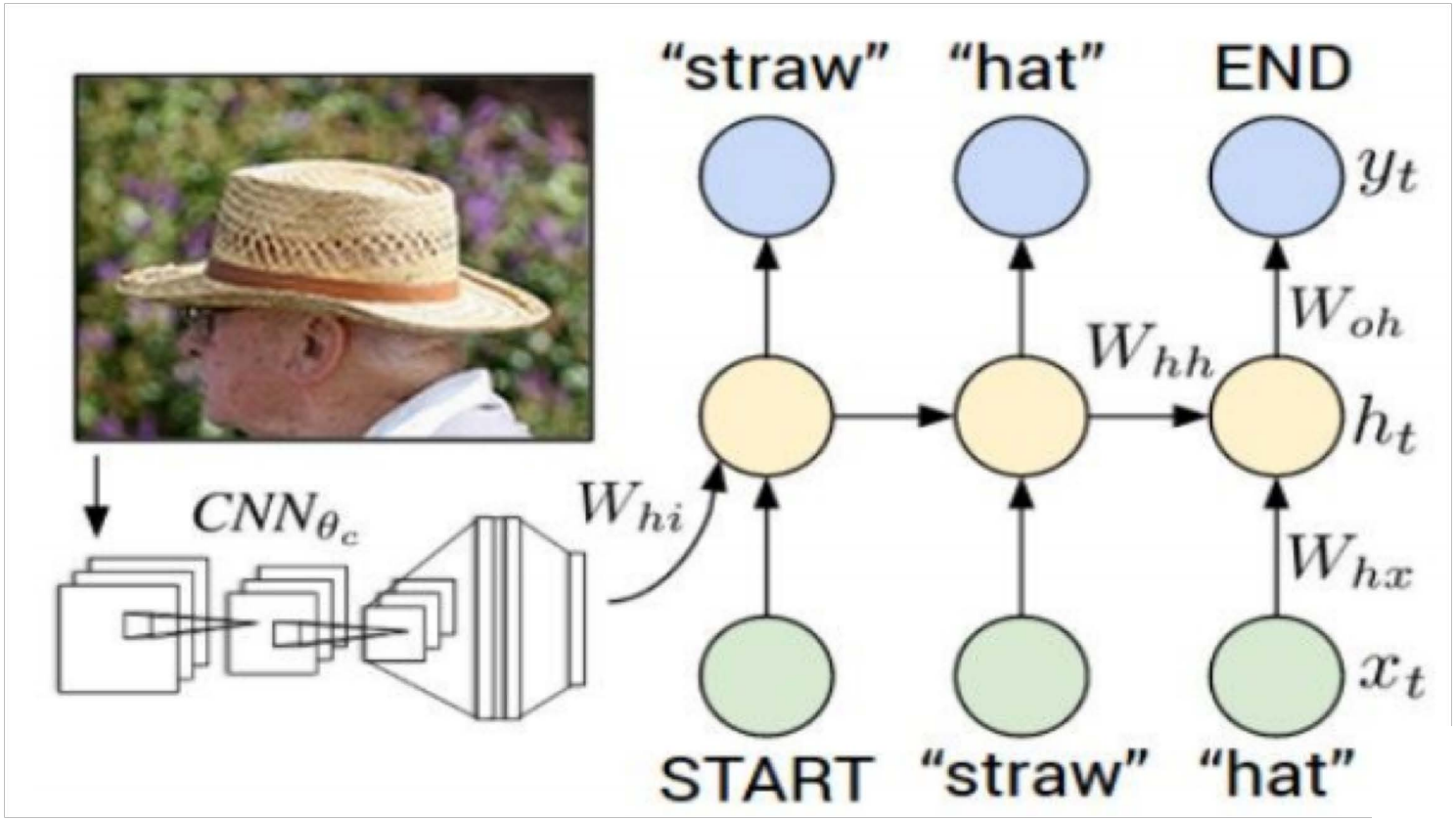


Image Captioning

This image is CC0 public domain

test image

Slides from Fei-Fei Li

Image Captioning

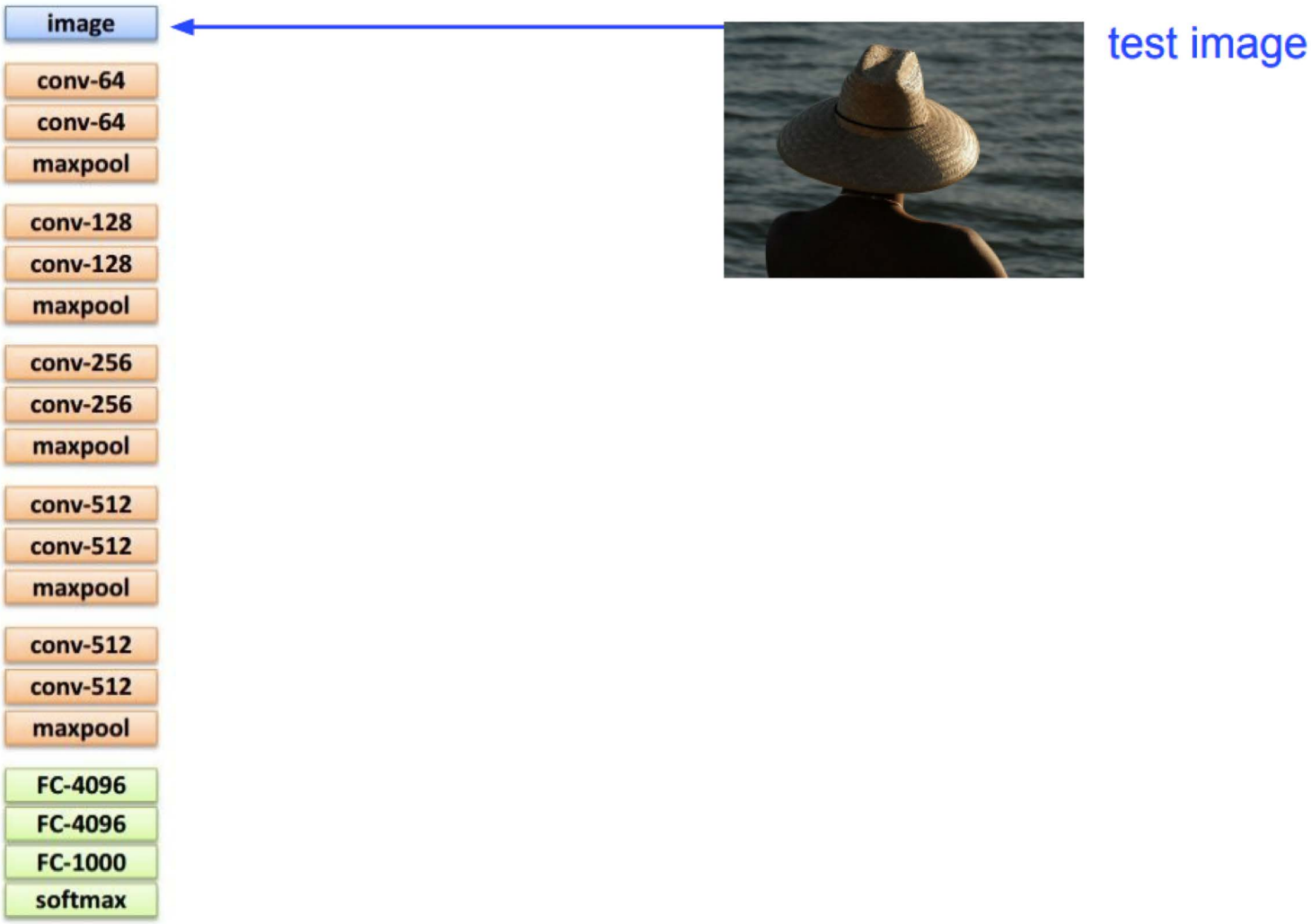


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Image Captioning

test image

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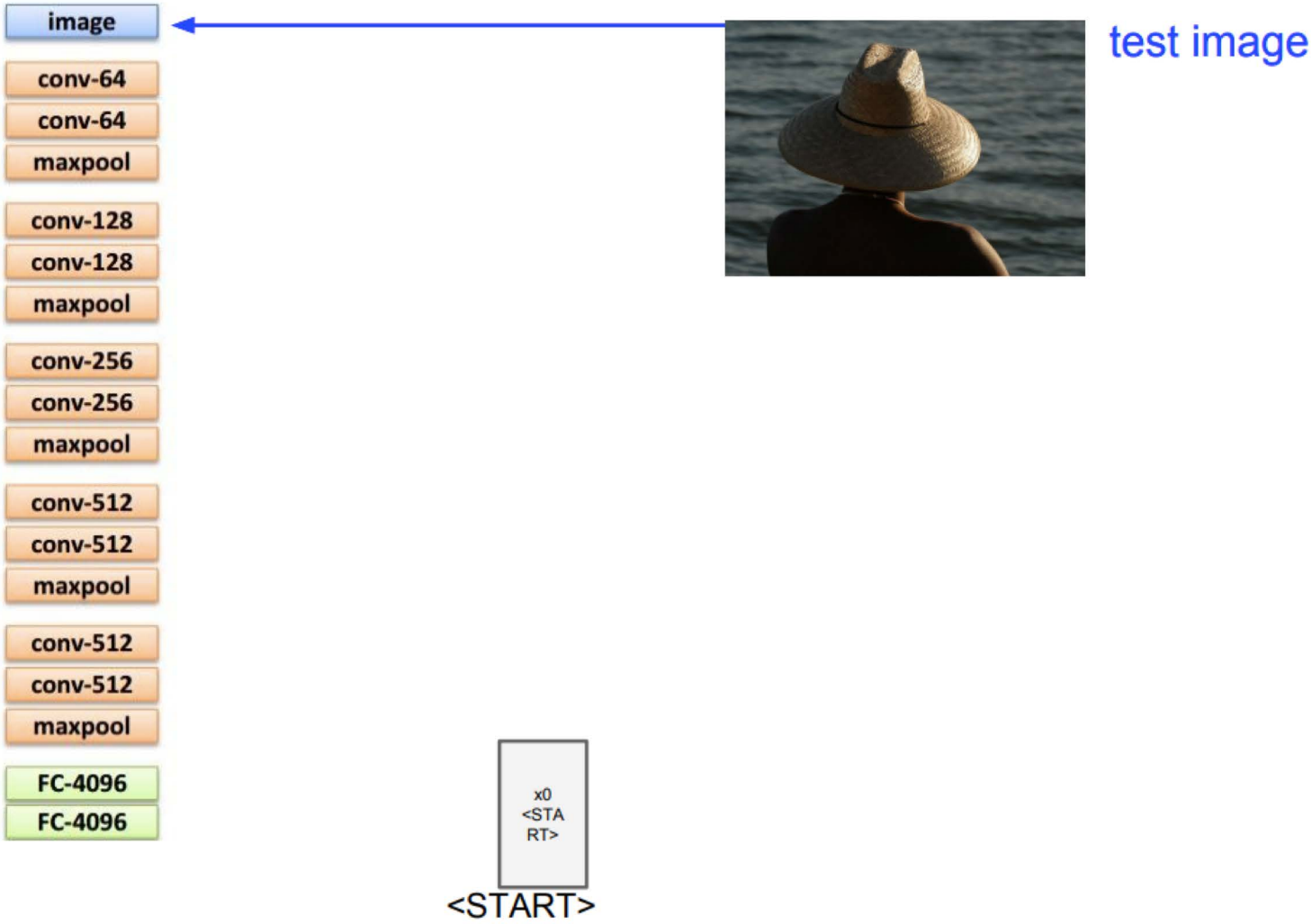
Image Captioning



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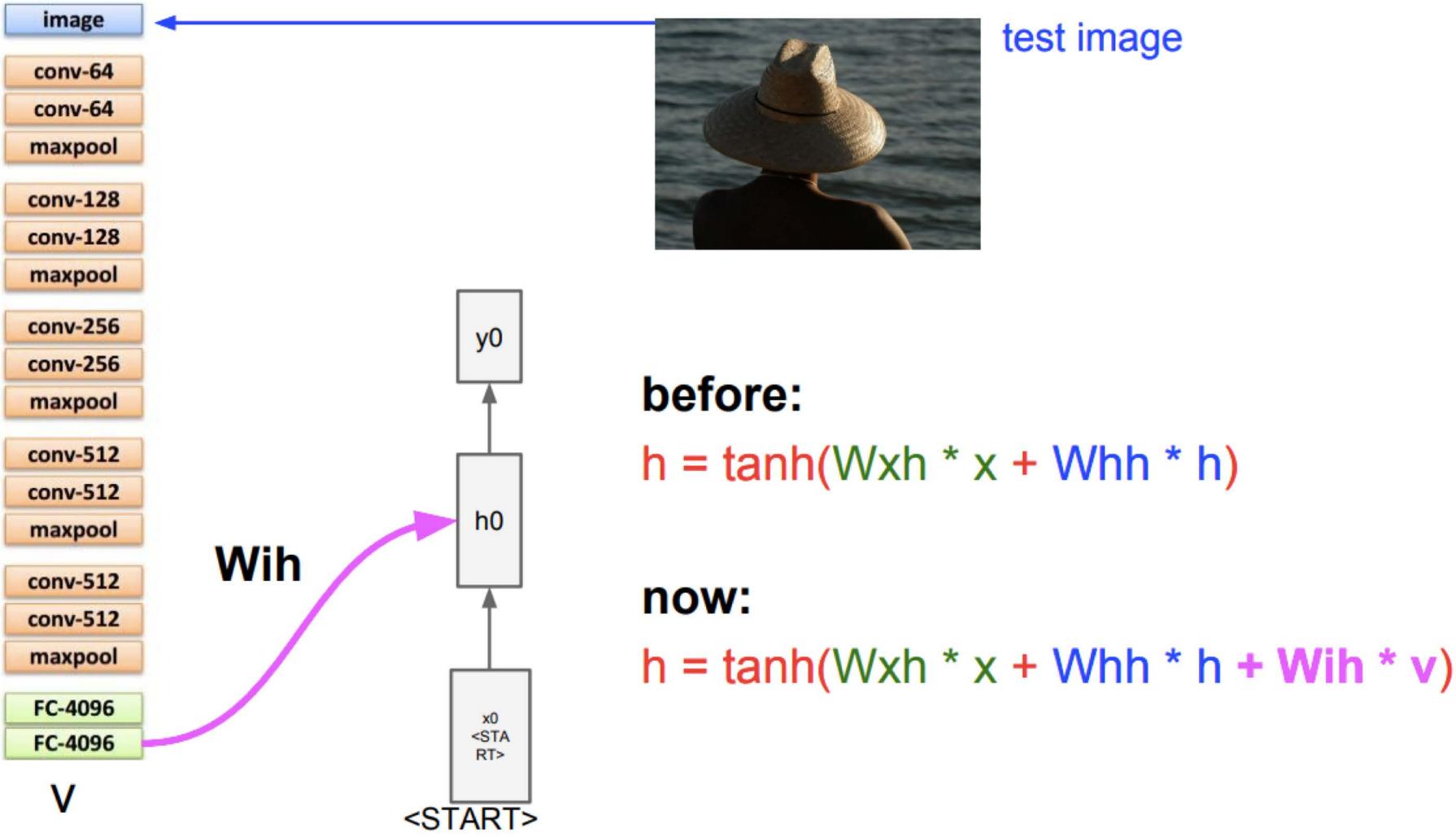

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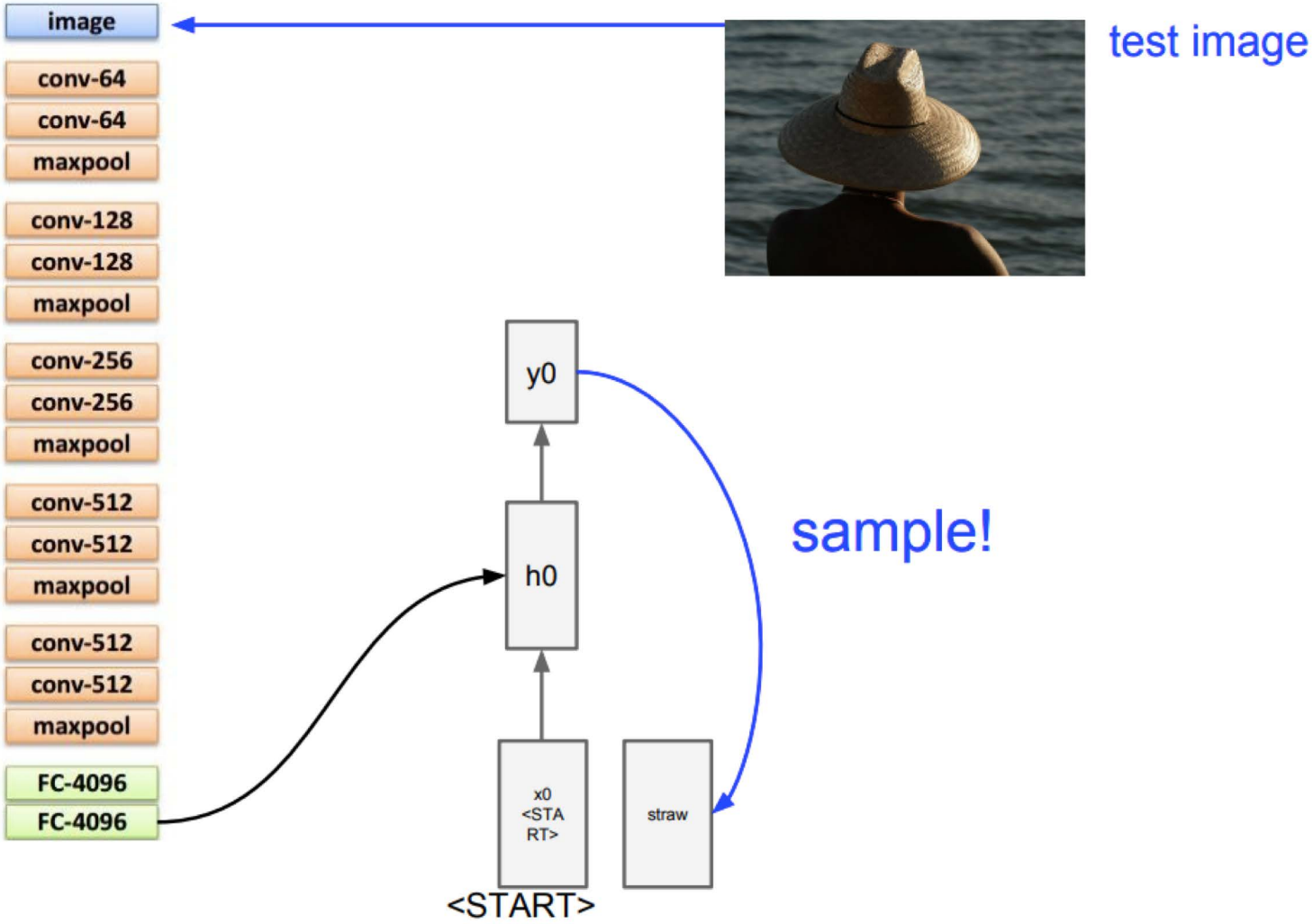

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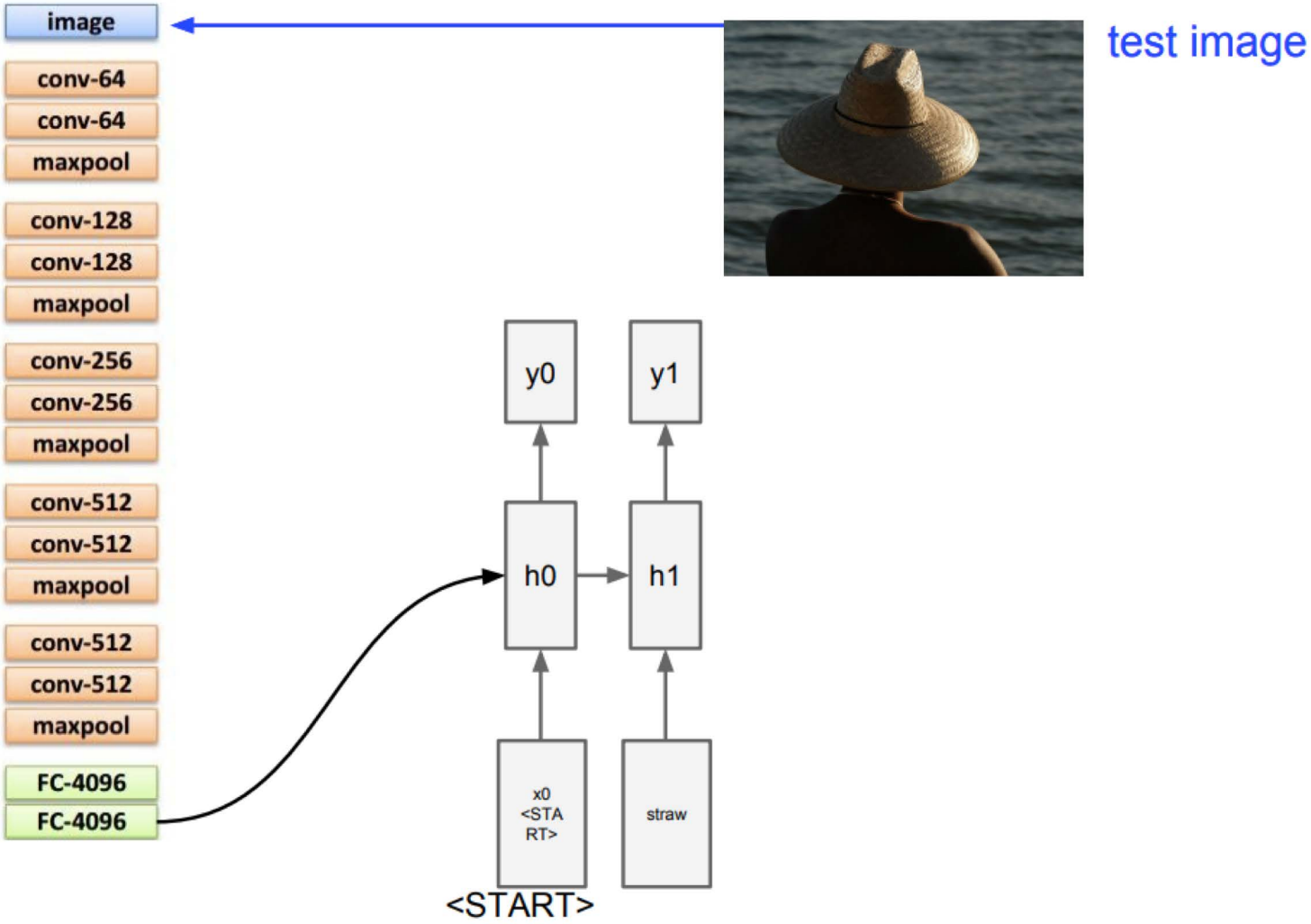

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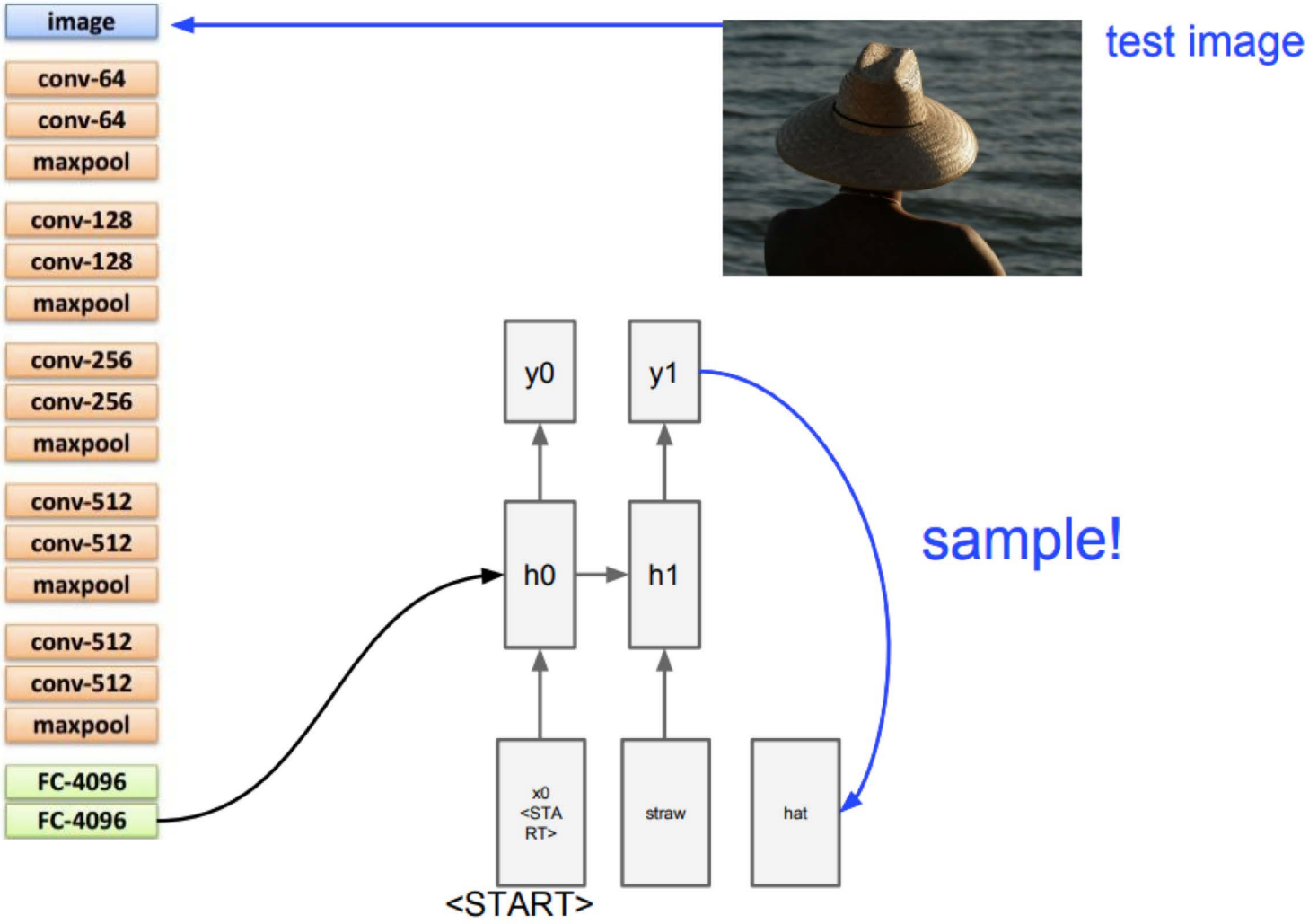

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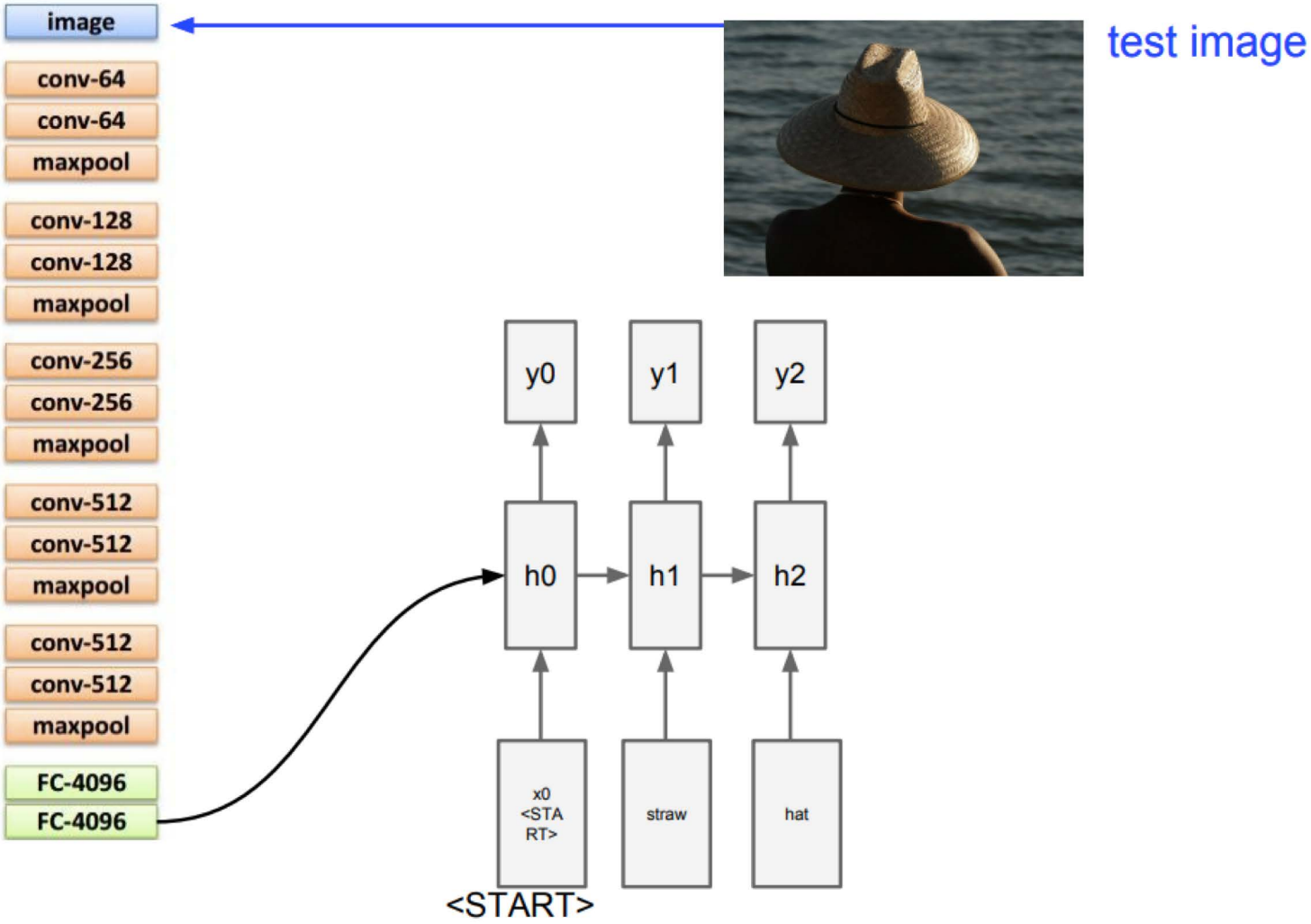

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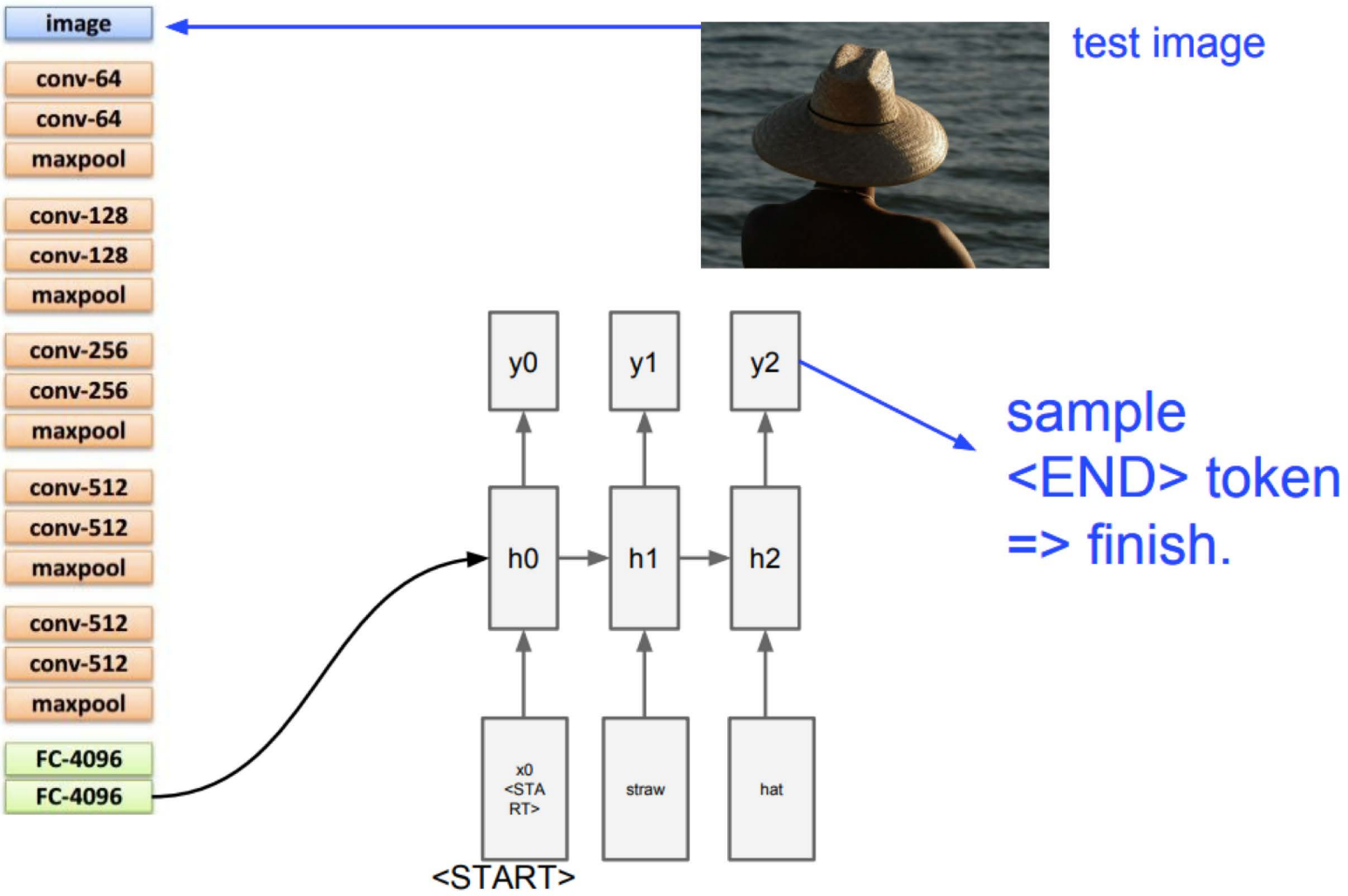

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Image Captioning Results

A cat sitting on a suitcase on the floor

A cat is sitting on a tree branch

A dog is running in the grass with a frisbee

A white teddy bear sitting in the grass

Two people walking on the beach with surfboards

A tennis player in action on the court

Two giraffes standing in a grassy field

A man riding a dirt bike on a dirt track

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