

- **Regression:** In this type of task, the computer program is asked to predict a numerical value given some input. To solve this task, the learning algorithm is asked to output a function $f : \mathbb{R}^n \rightarrow \mathbb{R}$. This type of task is similar to classification, except that the format of output is different. An example of a regression task is the prediction of the expected claim amount that an insured person will make (used to set insurance premiums), or the prediction of future prices of securities. These kinds of predictions are also used for algorithmic trading.
- **Transcription:** In this type of task, the machine learning system is asked to observe a relatively unstructured representation of some kind of data and transcribe it into discrete, textual form. For example, in optical character recognition, the computer program is shown a photograph containing an image of text and is asked to return this text in the form of a sequence of characters (e.g., in ASCII or Unicode format). Google Street View uses deep learning to process address numbers in this way (Goodfellow *et al.*, 2014d). Another example is speech recognition, where the computer program is provided an audio waveform and emits a sequence of characters or word ID codes describing the words that were spoken in the audio recording. Deep learning is a crucial component of modern speech recognition systems used at major companies including Microsoft, IBM and Google (Hinton *et al.*, 2012b).
- **Machine translation:** In a machine translation task, the input already consists of a sequence of symbols in some language, and the computer program must convert this into a sequence of symbols in another language. This is commonly applied to natural languages, such as translating from English to French. Deep learning has recently begun to have an important impact on this kind of task (Sutskever *et al.*, 2014; Bahdanau *et al.*, 2015).
- **Structured output:** Structured output tasks involve any task where the output is a vector (or other data structure containing multiple values) with important relationships between the different elements. This is a broad category, and subsumes the transcription and translation tasks described above, but also many other tasks. One example is parsing—mapping a natural language sentence into a tree that describes its grammatical structure and tagging nodes of the trees as being verbs, nouns, or adverbs, and so on. See Collobert (2011) for an example of deep learning applied to a parsing task. Another example is pixel-wise segmentation of images, where the computer program assigns every pixel in an image to a specific category. For