CLAIMS

1. A method comprising employing at least one hardware processor of a computer system to train an automatic natural language (NL) to artificial language (AL) translator, wherein training the NL-to-AL translator comprises:

performing a first stage of training;

determining whether a first stage training termination condition is satisfied according to at least one performance criterion in the first stage of training; and

in response, when the first stage training termination condition is satisfied, performing a second stage of training;

wherein performing the first stage of training comprises:

executing an AL encoder and a decoder coupled to the AL encoder, the AL encoder configured to receive a first input array comprising a representation of an input AL sentence formulated in an artificial language, and in response, to produce a first internal array, the decoder configured to receive the first internal array and in response, to produce a first output array comprising a representation of a first output AL sentence formulated in the artificial language;

in response to providing the first input array to the AL encoder, determining a first similarity score indicative of a degree of similarity between the input AL sentence and the first output AL sentence, and

adjusting a first set of parameters of the decoder according to the first similarity score to improve a match between AL encoder inputs and decoder outputs; and

wherein performing the second stage of training comprises:

executing a NL encoder configured to receive a second input array comprising a representation of an input NL sentence formulated in a natural language, and in response, to output a second internal array to the decoder;

determining a second output array produced by the decoder in response to receiving the second internal array, the second output array comprising a representation of a second output AL sentence formulated in the artificial language,

determining a second similarity score indicative of a degree of similarity between the second output AL sentence and a target AL sentence comprising a translation of the input NL sentence into the artificial language, and

adjusting a second set of parameters of the NL encoder according to the second similarity score to improve a match between decoder outputs and target outputs representing respective translations into the artificial language of inputs received by the NL encoder.

2. The method of claim 1, wherein the artificial language comprises an item selected from a group consisting of a database query language, a programming language, and a markup language.

3. The method of claim 2, wherein the artificial language is a structured query language (SQL).

4. The method of claim 1, further comprising determining the second similarity score according to a degree of similarity between the second output array and a target array comprising a representation of the target AL sentence.

5. The method of claim 1, wherein determining the second similarity score comprises employing at least one hardware processor of the computer system to:

input a representation of the target AL sentence to the AL encoder;

determine a third internal array comprising an output of the AL encoder in response to receiving the representation of the target AL sentence as input; and

determine the second similarity score according to a degree of similarity between the second and third internal arrays.

6. The method of claim 1, further comprising, in response to determining whether the first stage training termination condition is satisfied, if the first stage training termination condition is not satisfied, employing at least one hardware processor of the computer system to:

provide a third input array to the AL encoder, the third input array comprising a representation of a third AL sentence formulated in the artificial language;

determine a third output array comprising an output of the decoder in response to the AL encoder receiving the third input array, the third output array comprising a representation of a third output AL sentence;

determine a third similarity score indicative of a degree of similarity between the third input AL sentence and the third output AL sentence;

adjust the first set of parameters of the decoder according to the third similarity score, to improve a match between AL encoder inputs and decoder outputs.

7. The method of claim 1, further comprising, in response to performing the second stage of training, employing at least one hardware processor of the computer system to:

execute another NL encoder configured to receive a third input array comprising a representation of another NL sentence, and in response, to output a third internal array to the decoder, wherein the another NL sentence is formulated in another natural language distinct from the natural language;

determine a third output array produced by the decoder in response to receiving the third internal array, the third output array comprising a representation of a third output AL sentence;

determine a third similarity score indicative of a degree of similarity between the third output AL sentence and a third target AL sentence comprising a translation of the another NL sentence into the artificial language; and

adjust a third set of parameters of the another NL encoder according to the third similarity score to improve a match between decoder outputs and another set of target outputs representing respective translations into the artificial language of inputs received by the another NL decoder.

8. The method of claim 1, wherein the NL encoder comprises a recurrent neural network.

9. A computer system comprising at least one hardware processor and a memory, the at

least one hardware processor configured to train an automatic natural language (NL) to artificial language (AL) translator, wherein training the NL-to-AL translator comprises:

performing a first stage of training;

determining whether a first stage training termination condition is satisfied according to at least one performance criterion in the first stage of training; and

in response, when the first stage training termination condition is satisfied, performing a second stage of training;

wherein performing the first stage of training comprises:

executing an AL encoder and a decoder coupled to the AL encoder, the AL encoder configured to receive a first input array comprising a representation of an input AL sentence formulated in an artificial language, and in response, to produce a first internal array, the decoder configured to receive the first internal array and in response, to produce a first output array comprising a representation of a first output AL sentence formulated in the artificial language,

in response to providing the first input array to the AL encoder, determining a first similarity score indicative of a degree of similarity between the input AL sentence and the first output AL sentence, and adjusting a first set of parameters of the decoder according to the first similarity score to improve a match between AL encoder inputs and decoder outputs; and

wherein performing the second stage of training comprises:

executing a NL encoder configured to receive a second input array comprising a representation of an input NL sentence formulated in a natural language, and in response, to output a second internal array to the decoder,

determining a second output array produced by the decoder in response to receiving the second internal array, the second output array comprising a representation of a second output AL sentence formulated in the artificial language,

determining a second similarity score indicative of a degree of similarity between the second output AL sentence and a target AL sentence comprising a translation of the input NL sentence into the artificial language, and

adjusting a second set of parameters of the NL encoder according to the second similarity score to improve a match between decoder outputs and target outputs representing respective translations into the artificial language of inputs received by the NL encoder.

10. The computer system of claim 9, wherein the artificial language comprises an item selected from a group consisting of a database query language, a programming language, and a markup language.

11. The computer system of claim 10, wherein the artificial language is a structured query language (SQL).

12. The computer system of claim 9, wherein the at least one hardware processor is further configured to determine the second similarity score according to a degree of similarity between the second output array and a target array comprising a representation of the target AL sentence.

13. The computer system of claim 9, wherein determining the second similarity score comprises employing the at least one hardware processor of the computer system to:

input a representation of the target AL sentence to the AL encoder;

determine a third internal array comprising an output of the AL encoder in response to receiving the representation of the target AL sentence as input; and

determine the second similarity score according to a degree of similarity between the second and third internal arrays.

14. The computer system of claim 9, wherein the at least one hardware processor is further configured, in response to determining whether the first termination condition is satisfied, if the first termination condition is not satisfied, to:

provide a third input array to the AL encoder, the third input array comprising a representation of a third AL sentence formulated in the artificial language;

determine a third output array comprising an output of the decoder in response to the AL encoder receiving the third input array, the third output array comprising a representation of a third output AL sentence;

determine a third similarity score indicative of a degree of similarity between the third input AL sentence and the third output AL sentence;

adjust the first set of parameters of the decoder according to the third similarity score, to improve a match between AL encoder inputs and decoder outputs.

15. The computer system of claim 9, wherein the at least one hardware processor is further configured, in response to performing the second stage of training, to:

execute another NL encoder configured to receive a third input array, and in response, to output a third internal array to the decoder, wherein the another NL sentence is formulated in another natural language distinct from the natural language;

determine a third output array produced by the decoder in response to receiving the third internal array, the third output array comprising a representation of a third output AL sentence;

determine a third similarity score indicative of a degree of similarity between the third output AL sentence and a third target AL sentence comprising a translation of the another NL sentence into the artificial language; and

adjust a third set of parameters of the another NL encoder according to the third similarity score to improve a match between decoder outputs and another set of target outputs representing respective translations into the artificial language of inputs received by the another NL decoder.

16. The computer system of claim 9, wherein the NL encoder comprises a recurrent neural network.

17. A non-transitory computer-readable medium storing instructions which, when executed by a first hardware processor of a first computer system, cause the first computer system to form a trained natural language (NL) to artificial language (AL) translator module comprising a NL encoder and a decoder connected to the NL encoder, wherein training the

NL-to-AL translator module comprises employing a second hardware processor of a second computer system to:

perform a first stage of training;

determine whether a first stage training termination condition is satisfied according to at least one performance criterion in the first stage of training; and

in response, when the first stage training termination condition is satisfied, perform a second stage of training;

wherein performing the first stage of training comprises:

coupling the decoder to an artificial language (AL) encoder configured to receive a first input array comprising a representation of an input AL sentence formulated in an artificial language, and in response, to produce a first internal array, the AL encoder coupled to the decoder so that the decoder receives the first internal array and in response, produces a first output array comprising a representation of a first output AL sentence formulated in the artificial language,

in response to providing the first input array to the AL encoder, determining a first similarity score indicative of a degree of similarity between the input AL sentence and the first output AL sentence, and

adjusting a first set of parameters of the decoder according to the first similarity score to improve a match between AL encoder inputs and decoder outputs; and

wherein performing the second stage of training comprises:

coupling the NL encoder to the decoder so that the NL encoder receives a second input array comprising a representation of an input NL sentence formulated in a natural language, and in response, outputs a second internal array to the decoder,

determining a second output array produced by the decoder in response to receiving the second internal array, the second output array comprising a representation of a second output AL sentence formulated in the artificial language,

determining a second similarity score indicative of a degree of similarity between the second output AL sentence and a target AL sentence comprising a translation of the input NL sentence into the artificial language, and

adjusting a second set of parameters of the NL encoder according to the second similarity score to improve a match between decoder outputs and target outputs representing respective translations into the artificial language of inputs received by the NL encoder.

18. A computer system comprising a first hardware processor configured to execute a trained natural language (NL) to artificial language (AL) translator module comprising a NL encoder and a decoder connected to the NL encoder, wherein training the NL-to-AL translator module comprises employing a second hardware processor of a second computer system to:

perform a first stage of training;

determine whether a first stage training termination condition is satisfied according to at least one performance criterion in the first stage of training; and

in response, when the first stage training termination condition is satisfied, perform a second stage of training;

wherein performing the first stage of training comprises:

coupling the decoder to an AL encoder configured to receive a first input array comprising a representation of an input AL sentence formulated in an artificial language, and in response, to produce a first internal array, the AL encoder coupled to the decoder so that the decoder receives the first internal array and in response, produces a first output array comprising a representation of a first output AL sentence formulated in the artificial language,

in response to providing the first input array to the AL encoder, determining a first similarity score indicative of a degree of similarity between the input AL sentence and the first output AL sentence, and

adjusting a first set of parameters of the decoder according to the first similarity score to improve a match between AL encoder inputs and decoder outputs; and

wherein performing the second stage of training comprises:

coupling the NL encoder to the decoder so that the NL encoder receives a second input array comprising a representation of an input NL sentence formulated in a natural language, and in response, outputs a second internal array to the decoder,

determining a second output array produced by the decoder in response to receiving the second internal array, the second output array comprising a representation of a second output AL sentence formulated in the artificial language,

determining a second similarity score indicative of a degree of similarity between the second output AL sentence and a target AL sentence comprising a translation of the input NL sentence into the artificial language, and

adjusting a second set of parameters of the NL encoder according to the second similarity score to improve a match between decoder outputs and target outputs representing respective translations into the artificial language of inputs received by the NL encoder.