

WHAT IS CLAIMED IS:

1. A system, comprising:
 - a neural network encoder configured to generate encoded data from input data;
 - an environmental filter communicably connected with the encoder and configured to combine the encoded data with at least one randomized image to generate signature data corresponding to the input data; and
 - a neural network decoder configured to be trained together with the encoder and the environmental filter to decode the signature data to generate decoded data corresponding to the input data.
2. The system of claim 1, wherein
 - the at least one randomized image includes non-visual domain data representing at least one real-world condition under which the encoded data is to be captured before decoding.
3. The system of claim 2, wherein
 - the non-visual domain data include at least one of near infrared (NIR) noises, far infrared (FIR) noises, Light Detection And Ranging (LIDAR) noises, radar noises, or radio frequency (RF) noises.
4. The system of claim 1, wherein
 - the environmental filter is further configured to apply at least one randomized image transformation to the encoded data.
5. The system of claim 4, wherein
 - the at least one randomized image transformation includes at least one of distortion, skew, rescaling, rebalance, normalization, or equalization.

6. The system of claim 1, wherein
the encoder is a deconvolution neural network encoder, and
the decoder is a convolution neural network decoder.
7. A system, comprising:
a sensor on a vehicle configured to move along a guideway, the sensor configured to capture encoded data embedded in a marker installed along the guideway;
a trained neural network decoder on the vehicle, the decoder configured to decode the encoded data captured by the sensor to generate decoded data corresponding to input data encoded into the encoded data by a trained neural network encoder; and
a controller on the vehicle, the controller configured to control the vehicle based on the decoded data,
wherein the decoder and the encoder have been trained together with an environmental filter which combined encoded training data generated by the encoder in training with a plurality of randomized images to generate training signature data to be decoded by the decoder in training.
8. The system of claim 7, wherein
the sensor includes at least one of a near infrared (NIR) camera, a far infrared (FIR) camera, a Light Detection And Ranging (LIDAR) scanner, a radar scanner, or a radio frequency (RF) transceiver.
9. The system of claim 7, further comprising the encoder configured to be trained online with the decoder, wherein

the encoder is configured to encode input training data into encoded training data to be embedded in a marker and captured by the sensor,

the decoder is configured to decode the encoded training data captured by the sensor to generate decoded training data, and

the encoder and the decoder are configured to be fine-tuned based on the input training data and the decoded training data.

10. The system of claim 7, further comprising:

the marker which is a variable marker in which the embedded encoded data is electrically variable.

11. The system of claim 10, further comprising:

a wayside controller communicably connected with the variable marker,

wherein the wayside controller comprises the encoder configured to

generate encoded updated data in response to updated data intended for the vehicle and received at the wayside controller, and

communicate the encoded updated data to the variable marker to embed the encoded updated data therein.

12. The system of claim 7, further comprising:

the marker which is a static marker having the encoded data permanently embedded therein.

13. A method, comprising:

training a neural network encoder, a neural network decoder, and an environmental filter together, said training comprising:

generating, by the encoder, a plurality of sets of encoded training data corresponding to a plurality of sets of input training data,

combining, by the environmental filter, randomized images in a non-visual domain with the plurality of sets of encoded training data to generate a plurality of sets of training signature data,

decoding, by the decoder, the plurality of sets of training signature data to generate a plurality of sets of decoded training data, and

optimizing the encoder and the decoder based on the plurality of sets of input training data, the randomized images, and the plurality of sets of decoded training data.

14. The method of claim 13, further comprising, after said training which is offline training,

online training the offline-trained encoder and the offline-trained decoder together, said online training comprising:

deploying the offline-trained decoder on a vehicle;

capturing, by a sensor on the vehicle, further encoded training data embedded in a marker along a route of the vehicle, the further encoded training data generated by the offline-trained encoder from further input training data;

decoding, by the offline-trained decoder, the further encoded training data to generate further decoded training data; and

fine-tuning the offline-trained encoder and the offline-trained decoder based on the further input training data and the further decoded training data.

15. The method of claim 14, wherein
- the sensor is configured to capture data in the non-visual domain, and
 - the randomized images in the non-visual domain represent a real-world condition under which encoded data generated by the encoder is to be captured by the sensor for decoding by the decoder.
16. The method of claim 13, further comprising:
- deploying the trained decoder on a vehicle;
 - capturing, by a sensor on the vehicle, encoded data embedded in a marker along a route of the vehicle, the encoded data generated by the trained encoder from input data;
 - decoding, by the trained decoder, the encoded data to generate decoded data corresponding to the input data; and
 - controlling the vehicle based on the decoded data.
17. The method of claim 16, further comprising:
- embedding the encoded data into the marker in an electrically changeable manner.
18. The method of claim 17, further comprising:
- in response to updated data intended for the vehicle, generating, by the trained encoder, encoded updated data from the updated data; and
 - communicating the encoded updated data to the marker to embed the encoded updated data therein.

19. The method of claim 16, further comprising:
permanently embedding the encoded data into the marker.
20. The method of claim 16, wherein
the input data includes input information for controlling the vehicle, and an integrity signature of the input information, and
the decoded data includes decoded information corresponding to the input information, and a decoded integrity signature corresponding to the integrity signature of the input information,
the method further comprising verifying data integrity based on the decoded integrity signature and an integrity signature calculated from the decoded information.