senseEDGE™

Object Data Format Specification

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Protocol Version 1.1

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Document History

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April 2024	2.2	1.1	Simon Tilbury	Add tracking IDs to zones Change to UTC timezone
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1 Introduction

1.1 Scope

This document describes the structure and format of the object data output delivered by Cron AI's senseEDGE™ 3D perception platform. senseEDGE™ uses 3D sensors and Deep Learning techniques to detect, classify and track objects with a high degree of accuracy to give robust and reliable results.

1.2 Intended Audience

This document is intended for use by a consumer of object data from senseEDGE™ and as such defines the format and content of the output messages which will be produced.

2 Structure and Transport

One message is produced per frame, each containing information about the frame, zone counts and a list of objects, with one entry for each object which was detected. Frame frequency is dependent on the sensor and scan pattern selected, typically 10 frames per second (FPS).

Messages are transported over websockets, which are hosted on senseEDGE™, and will accept connections from any address. Websockets operate over a TCP connection, using HTTP for initial handshaking.

A client needs to connect to the appropriate websocket URL in order to receive object data messages. Library classes for connecting to websockets are available in most common programming languages (javascript, python, C++ boost etc.).

The following table lists the URLs for websockets corresponding to specific formats and software release:

Format	URL[1]	Software Release
JSON	`ws://1.2.3.4:5281/stream/object`	Up to 1.3.0
JSON	`wss://1.2.3.4/stream/object/json`	1.3.1 and later
XML	Available on request	Any
Flatbuffers	`wss://1.2.3.4/stream/object/fbs`	1.5.0 and later

[1] *IP address 1.2.3.4 used for illustration; default ports unless specified*

3 Format

Output from senseEDGE™ can be configured for a number of formats as detailed in the following sections. Selected extracts from the JSON format are used within this document for the purposes of illustration.

3.1 JSON

JavaScript Object Notation (JSON) is an open standard which comprises a human readable data interchange format. The JSON format comprises attribute-value pairs and arrays. JSON is language independent and well supported across a range of common programming languages. A sample JSON message is included in section 7 Sample JSON Message.

3.2 XML

Extensible Markup Language (XML) is an open standard which comprises human readable data interchange and storage format. The XML format comprises tags which contain elements and may contain attributes (although attributes are not used in this case). XML is language independent and well supported across a range of common programming languages. A sample XML message is included in section 8 Sample XML Message.

3.3 Binary (Flatbuffers)

Flatbuffers provides a binary output format which is more bandwidth efficient, at the cost of human readability. Flatbuffers messages can also be faster to deserialise since it is not necessary to parse text. The Flatbuffers schema is detailed in section 6 Flatbuffers Schema

See https://flatbuffers.dev/ for further details and a list of support across different programming languages.

4 Fields

4.1 Meta

The meta field contains information about the file and its contents,

```
"meta": {
    "version": "1.1",
    "datetime": "2024-01-11 10:57:46.027500Z",
    "frame_count": 1,
    "object_count": 23
```

```
},
```

4.1.1 Version

Version of the protocol in use. This will be updated in future as additional fields are added or should any fields change. The version should be checked before processing to ensure that fields are interpreted correctly.

4.1.2 Date and Time

Date and time of the message as Coordinated Universal Time (UTC) without offset, regardless of locality (`UTC±00:00` or Zulu time), in the format:

`YYYY-MM-DD HH:MM:SS.SSSSSSZ`

4.1.3 Frame Count

The number of frames contained within the file (usually 1).

4.1.4 Object Count

The number of objects contained within the file. Note that if the file contains data for more than one frame, there may be multiple entries for a single object. The count is the total number of object updates included across all frames.

4.2 Payload

The payload contains a list of all frames in the message.

```
"payload": [
    {
```

4.2.1 Sensors

List of sensors and corresponding frame IDs which contributed to the frame. This is primarily used by the senseEdge Visualiser in order to synchronise object data with corresponding points from the sensors.

```
"sensors": [
    {
        "sensor_id": 0,
        "frame_id": 514074
    }
],
```

4.2.1.1 Sensor ID

Unique identifier for the sensor.

4.2.1.2 Frame ID

Unique identifier for the frame specific to the sensor as a sequential numeric count.

4.2.2 Objects

List of objects contained within the frame. Note that each detected object will have a single entry only per frame regardless of how many sensors contributed points which were used to achieve the detection.

For each object the fields defined in the following sections may be present.

```
"objects": [
    {
        "tracking_id": "b98b6742-fce0-48ec-aab7-5cc1f9a16260",
```

4.2.2.1 Tracking ID

Unique ID for the object. The tracking ID will persist across frames as an object is tracked, and can be used to identify the same object over time. This includes when an object is occluded for a period of time, e.g. a person walking behind a pillar.

Tracking IDs are generated randomly using a UUID library, which should ensure that IDs are universally unique, and are not recycled over time.

4.2.2.2 Position

Position of the centre of the detected object relative to a fixed reference point (usually the point on the ground beneath the sensor where a single sensor is used).

```
"position": {
    "xyz": [
        -43.891,
        28.221,
        0.389
    ],
    "sigma": 1.38
},
```

4.2.2.2.1 X / Y / Z

Cartesian distance of the centre of the object from the reference point in metres.

4.2.2.2.2 Sigma

Standard deviation for the cartesian position estimate (in x and y axis).

4.2.2.2.3 Unit (optional)

Textual representation of the unit of measurement.

4.2.2.3 Dimension

Cuboid size of the bounding box around the detected object.

```
"dimension": {
    "lwh": [
        0.709,
        0.731,
        1.697
    ]
},
```

4.2.2.3.1 L / W / H

Dimension (length/width/height) of the bounding box in metres.

4.2.2.3.2 Unit (optional)

Textual representation of the unit of measurement.

4.2.2.4 Orientation

Rotation of the object in the Z axis, and indication of which way the object is facing relative to a fixed reference point (usually the sensor where a single sensor is used).

```
"orientation": {
    "yaw": 0.196,
    "sigma": 1.21
},
```

4.2.2.4.1 Yaw

Yaw angle (rotation) of the object, relative to the X axis, in radians.

4.2.2.4.2 Unit (optional)

Textual representation of the unit of measurement.

4.2.2.4.3 Sigma

Standard deviation for the yaw angle estimate.

4.2.2.5 Classification

The determined class of the object which has been detected.

See section 5 Class List for a list of supported classes and corresponding codes

```
"classification": {
    "code": "0110",
    "description": "Adult",
    "confidence": 1.0
},
```

4.2.2.5.1 Classification Code

Code corresponding to the determined class.

4.2.2.5.2 Textual Description

Textual description of the determined class.

4.2.2.5.3 Confidence

Measure of confidence in the determination of the object class in range 0 to 1.

4.2.2.6 Distance

Distance to the sensor in metres, or nearest sensor where multiple sensors are used for detection

```
"distance": 52.246,
```

4.2.2.7 Velocity

Velocity of the object (speed and heading). Note that heading is not necessarily the same as Orientation, as the object may be moving in a direction other than forwards.

```
"velocity": {
    "speed": 1.356,
    "heading": -1.077,
    "sigma": 0.54,
    "dynamic_probability": 1.0
},
```

4.2.2.7.1 Speed

Speed of the object in metres per second.

4.2.2.7.2 Heading

Heading (direction of travel) of the object, relative to the X axis, in radians.

4.2.2.7.3 Unit (optional)

Textual representation of the unit(s) of measurement.

4.2.2.7.4 Sigma

Standard deviation for the speed and heading estimate.

4.2.2.7.5 Dynamic Probability

Probability that the object is currently dynamic (i.e. likely to be moving beyond measurement noise levels) in the range 0 to 1. Objects that have been moving in the past but are not moving at the moment are still considered to be dynamic for a period of up to 5 minutes.

4.2.2.8 Maturity

The maturity of the object, a combination of age and likelihood.

```
"maturity": {
    "age": 8.5,
    "count": 85,
    "confidence": 0.31
}
```

4.2.2.8.1 Age

Time since the object was first detected in seconds.

4.2.2.8.2 Unit (optional)

Textual representation of the unit of measurement.

4.2.2.8.3 Count

Number of measurement cycles (frames) during which the object has been detected.

4.2.2.8.4 Confidence

Measure of detection confidence in the range 0 to 1. A confidence level of 0,5 or greater is considered worthy of showing, and use of objects with a value below 0.5 is discouraged.

4.2.3 Zones

List of zones and corresponding statistical counts.

```
"zones": [
```

```
    {
        "zone_id": 3,
```

4.2.3.1 Zone ID

Unique identifier for the zone.

4.2.3.2 Counts

Statistical counts corresponding to the zone.

```
"counts": {
    "cumulative": 48,
    "this_frame": 1
}
```

4.2.3.2.1 Cumulative

The total number of unique objects detected for the zone since last reset.

4.2.3.2.2 This Frame

The number of unique objects detected for the zone in this frame.

4.2.3.3 Tracking IDs

Tracking IDs for objects detected for the zone in this frame.

```
"tracking_ids": [
    "e4fe60d5-fd21-4349-9c04-7abdf59b37ea",
    "10d220b5-d970-48d6-b019-a47ee49fac6a",
    "a4d13038-85cc-4370-914b-a0a6e6fc452e",
    "588c9a1a-0514-483b-88fe-494f82afdd96"
]
```

4.2.4 Dropped IDs

Tracking IDs for objects which have been dropped (i.e. no longer tracked) as of the current frame.

```
"dropped_ids": [
    "078bd4be-add6-4cab-aa26-99eba0330728",
    "3282220e-7461-4672-8c63-79f962bcaa54"
]
```

Once dropped, no further updates are expected for the object, since it will no longer be tracked. Any objects which remain undetected for long enough to be dropped but are subsequently detected again are considered new objects, and will be allocated a new tracking ID accordingly.

5 Class List

The following classes and groups are currently supported, depending on the software release. Additional object classes (and sub-classes) will be added over time. In particular more general classes will be used first, with objects placed in the nearest matching class. E.g. a small van may be classified as a car and a child may be classified as an adult; this is represented by the hierarchical nature of the associated codes (e.g. 04XX -> 0410 -> 0413). Greater granularity of classes will be added in future versions.

Please check with your representative for details of classes supported and identified by a specific release.

5.1 People 01XX

Human Beings in general or human-like characters (e.g. a shop mannequin or statue). The front of the bounding box is aligned with the front of the chest or the person. People are identified separately from the objects they may be riding or driving (e.g. a bicycle and its rider are separate objects).

5.1.1 Adult (0110)

An adult sized Human Being. This includes people who may be walking with a stick or crutch, or may be sitting on a chair or bench, or riding a vehicle.

5.2 Semi Vehicles 03XX

A device which is used to transport a person or to enable (typically faster) movement other than walking. Often mixes with pedestrian traffic.

5.2.1 Bicycle (0320)

Any type of normal bicycle, typically narrow and with two wheels. Includes both upright and recumbent cycles. The bounding box does *not* include the rider(s).

5.3 Road Vehicle 04XX

A motorised vehicle which usually travels on a road or track. The front of the bounding box is the front of the vehicle and excludes extended or moveable parts of the vehicle, e.g. side mirrors; opened doors, boot or trunk; extendable arms or cranes and transported goods which extend over the vehicle's cargo space.

5.3.1 Car (0410)

Any car-like vehicle for the transportation of people and goods. Typically has a closed passenger compartment, four wheels, propelled by an engine and has a seating capacity

of less than eight persons. Examples include cars, minivans, station wagons, pick-up trucks, SUVs and 4x4s.

5.3.2 Van (0413)

Small to medium sized light industrial vehicle for the transportation of people and goods. Typically has a closed passenger compartment, four wheels and an enclosed back rather than windows.

5.3.3 Motorcycle (0420)

An open motorised vehicle which is typically narrow and has two wheels with the rider sitting (rather than standing) on the vehicle while driving. The bounding box excludes the rider(s) and any cargo.

5.3.4 Truck (0430)

A larger vehicle made for the transport of goods. The cabin is typically separate from the goods compartment on a common chassis or with a tractor and separate trailer (semi-truck, which is expected to become a distinct class of its own in future). The goods can be transported in an open or closed compartment.

5.3.5 Bus (0440)

A vehicle for the transportation of eight or more passengers. For articulated buses with a middle hinge, each segment of the vehicle may be identified individually.

6 Flatbuffers Schema

```
namespace cronai.io.fbs;

table Meta {
    version:string;
    datetime:string;
    frame_count:uint16;
    object_count:uint32;
}

table Payload {
    sensors:[SensorFrameId];
    objects:[Object];
    zones:[Zone];
    dropped_ids:[TrackingID];
}

table OutputFrameData {
    meta:Meta;
    payload:[Payload];
    version:uint16;
}

struct SensorFrameId {
    sensor_id: uint8;
    frame_id: uint64;
}

table Object {
    tracking_id:TrackingID;
    position:Position;
    dimension:Dimension;
    orientation:Orientation;
    classification:Classification;
    distance:float;
    velocity:Velocity;
    maturity:Maturity;
}

struct TrackingID {
    tracking_id:[ubyte:36];
}

table Position {
    xyz:[float];
    sigma:float;
    units:string;
}

table Dimension {
    lwh:[float];
    units:string;
}
```

```
table Orientation {
    yaw:float;
    sigma:float;
    units:string;
}

table Classification {
    code:string;
    description:string;
    confidence:float;
}

table Velocity {
    speed:float;
    heading:float;
    sigma:float;
    dynamic_probability:float;
    units:string;
}

table Maturity {
    age:float;
    count:uint32;
    confidence:float;
    units:string;
}

table Zone {
    zone_id:uint32;
    counts:ZoneCounts;
    tracking_ids:[TrackingID];
}

struct ZoneCounts
{
    cumulative:uint32;
    this_frame:uint32;
}

root_type OutputFrameData;
```

7 Sample JSON Message


```
{
    "meta": {
        "version": "1.1",
        "datetime": "2024-01-11 10:57:46.027500Z",
        "frame_count": 1,
        "object_count": 8
    },
    "payload": [
        {
            "sensors": [
                {
                    "sensor_id": 0,
                    "frame_id": 514074
                }
            ],
            "objects": [
                {
                    "tracking_id": "b98b6742-fce0-48ec-aab7-5cc1f9a16260",
                    "position": {
                        "xyz": [
                            -43.891,
                            28.221,
                            0.389
                        ],
                        "sigma": 1.38
                    },
                    "dimension": {
                        "lwh": [
                            0.709,
                            0.731,
                            1.697
                        ]
                    },
                    "orientation": {
                        "yaw": 0.196,
                        "sigma": 1.21
                    },
                    "classification": {
                        "code": "0110",
                        "description": "Adult",
                        "confidence": 1.0
                    },
                    "distance": 52.246,
                    "velocity": {
                        "speed": 0.0,
                        "heading": 0.0,
                        "sigma": 0.29,
                        "dynamic_probability": 0.0
                    },
                    "maturity": {
                        "age": 18.4,
                        "count": 184,
                        "confidence": 0.31
                    }
                },
                {
```

```
            "tracking_id": "e4fe60d5-fd21-4349-9c04-7abdf59b37ea",
            "position": {
                "xyz": [
                    -35.665,
                    7.275,
                    0.525
                ],
                "sigma": 0.12
            },
            "dimension": {
                "lwh": [
                    0.715,
                    0.73,
                    1.717
                ]
            },
            "orientation": {
                "yaw": 5.701,
                "sigma": 0.46
            },
            "classification": {
                "code": "0110",
                "description": "Adult",
                "confidence": 1.0
            },
            "distance": 36.484,
            "velocity": {
                "speed": 1.356,
                "heading": -1.077,
                "sigma": 0.54,
                "dynamic_probability": 1.0
            },
            "maturity": {
                "age": 8.5,
                "count": 85,
                "confidence": 1.0
            }
        },
        {
            "tracking_id": "cceb0adf-9ddf-418d-a7c1-ed2e965bb3e9",
            "position": {
                "xyz": [
                    3.519,
                    -5.18,
                    1.75
                ],
                "sigma": 0.32
            },
            "dimension": {
                "lwh": [
                    8.797,
                    2.741,
                    2.88
                ]
            },
            "orientation": {
                "yaw": 0.503,
                "sigma": 0.03
            },
            "classification": {
```

```
                    "code": "0430",
                    "description": "Truck",
                    "confidence": 1.0
                },
                "distance": 6.385,
                "velocity": {
                    "speed": 0.002,
                    "heading": -1.616,
                    "sigma": 0.42,
                    "dynamic_probability": 0.0
                },
                "maturity": {
                    "age": 75.2,
                    "count": 752,
                    "confidence": 1.0
                }
            },
            {
                "tracking_id": "10d220b5-d970-48d6-b019-a47ee49fac6a",
                "position": {
                    "xyz": [
                        -18.608,
                        2.526,
                        0.772
                    ],
                    "sigma": 0.43
                },
                "dimension": {
                    "lwh": [
                        3.6,
                        1.719,
                        1.424
                    ]
                },
                "orientation": {
                    "yaw": 2.158,
                    "sigma": 0.14
                },
                "classification": {
                    "code": "0410",
                    "description": "Car",
                    "confidence": 1.0
                },
                "distance": 18.91,
                "velocity": {
                    "speed": 1.848,
                    "heading": 2.126,
                    "sigma": 1.4,
                    "dynamic_probability": 0.59
                },
                "maturity": {
                    "age": 41.3,
                    "count": 413,
                    "confidence": 1.0
                }
            },
            {
                "tracking_id": "2163abb7-59cb-498d-b692-b5887eaabe94",
                "position": {
                    "xyz": [
```



```
                    -15.005,
                    -5.623,
                    0.733
                ],
                "sigma": 1.99
            },
            "dimension": {
                "lwh": [
                    3.808,
                    1.768,
                    1.44
                ]
            },
            "orientation": {
                "yaw": 2.412,
                "sigma": 0.21
            },
            "classification": {
                "code": "0410",
                "description": "Car",
                "confidence": 1.0
            },
            "distance": 16.184,
            "velocity": {
                "speed": 0.0,
                "heading": 3.142,
                "sigma": 0.87,
                "dynamic_probability": 0.06
            },
            "maturity": {
                "age": 21.8,
                "count": 218,
                "confidence": 0.15
            }
        },
        {
            "tracking_id": "a4d13038-85cc-4370-914b-a0a6e6fc452e",
            "position": {
                "xyz": [
                    -27.851,
                    -11.572,
                    0.651
                ],
                "sigma": 0.17
            },
            "dimension": {
                "lwh": [
                    0.633,
                    0.673,
                    1.634
                ]
            },
            "orientation": {
                "yaw": 0.203,
                "sigma": 1.01
            },
            "classification": {
                "code": "0110",
                "description": "Adult",
                "confidence": 1.0
```

```
            },
            "distance": 30.25,
            "velocity": {
                "speed": 0.49,
                "heading": 0.555,
                "sigma": 0.53,
                "dynamic_probability": 0.34
            },
            "maturity": {
                "age": 0.6,
                "count": 6,
                "confidence": 0.56
            }
        },
        {
            "tracking_id": "3f5f22ac-3b3b-4ecb-acf2-289bf438171a",
            "position": {
                "xyz": [
                    -9.471,
                    -0.286,
                    1.375
                ],
                "sigma": 0.21
            },
            "dimension": {
                "lwh": [
                    5.441,
                    2.093,
                    2.488
                ]
            },
            "orientation": {
                "yaw": 5.126,
                "sigma": 0.05
            },
            "classification": {
                "code": "0430",
                "description": "Truck",
                "confidence": 1.0
            },
            "distance": 9.613,
            "velocity": {
                "speed": 0.703,
                "heading": -0.95,
                "sigma": 0.71,
                "dynamic_probability": 0.8
            },
            "maturity": {
                "age": 9.3,
                "count": 93,
                "confidence": 1.0
            }
        },
        {
            "tracking_id": "588c9a1a-0514-483b-88fe-494f82afdd96",
            "position": {
                "xyz": [
                    -23.325,
                    36.687,
                    0.619
```



```
                    ],
                    "sigma": 0.36
                },
                "dimension": {
                    "lwh": [
                        4.1,
                        1.916,
                        1.526
                    ]
                },
                "orientation": {
                    "yaw": 5.509,
                    "sigma": 0.15
                },
                "classification": {
                    "code": "0410",
                    "description": "Car",
                    "confidence": 1.0
                },
                "distance": 43.539,
                "velocity": {
                    "speed": 4.099,
                    "heading": -0.714,
                    "sigma": 1.36,
                    "dynamic_probability": 1.0
                },
                "maturity": {
                    "age": 1.3,
                    "count": 13,
                    "confidence": 1.0
                }
            }
        ],
        "zones": [
            {
                "zone_id": 4,
                "counts": {
                    "cumulative": 40,
                    "this_frame": 0
                },
                "tracking_ids": [
                ]
            },
            {
                "zone_id": 5,
                "counts": {
                    "cumulative": 0,
                    "this_frame": 0
                },
                "tracking_ids": [
                ]
            },
            {
                "zone_id": 6,
                "counts": {
                    "cumulative": 9,
                    "this_frame": 0
                },
                "tracking_ids": [
                ]
```

```
                },
                {
                    "zone_id": 1,
                    "counts": {
                        "cumulative": 68,
                        "this_frame": 4
                    },
                    "tracking_ids": [
                        "e4fe60d5-fd21-4349-9c04-7abdf59b37ea",
                        "10d220b5-d970-48d6-b019-a47ee49fac6a",
                        "a4d13038-85cc-4370-914b-a0a6e6fc452e",
                        "588c9a1a-0514-483b-88fe-494f82afdd96"
                    ]
                },
                {
                    "zone_id": 2,
                    "counts": {
                        "cumulative": 2,
                        "this_frame": 0
                    },
                    "tracking_ids": [
                    ]
                },
                {
                    "zone_id": 3,
                    "counts": {
                        "cumulative": 48,
                        "this_frame": 1
                    },
                    "tracking_ids": [
                        "3f5f22ac-3b3b-4ecb-acf2-289bf438171a"
                    ]
                }
            ],
            "dropped_ids": [
                "078bd4be-add6-4cab-aa26-99eba0330728",
                "3282220e-7461-4672-8c63-79f962bcaa54"
            ]
        }
    ]
}
```

8 Sample XML Message

```
<?xml version="1.0" ?>
<root>
   <meta>
      <version>1.1</version>
      <datetime>2022-02-18 18:45:29.469927Z</datetime>
      <frame_count>1</frame_count>
      <object_count>2</object_count>
   </meta>
   <payload>
      <frame>
         <sensors>
            <sensor>
               <sensor_id>0</sensor_id>
               <frame_id>71693</frame_id>
            </sensor>
         </sensors>
         <objects>
            <object>
               <tracking_id>95b36139-af79-46de-83c9-e89f929e566d</tracking_id>
               <position>
                  <xyz>
                      <x>17.305</x>
                      <y>1.054</y>
                      <z>-2.962</z>
                  </xyz>
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