

## (12) Indian Patent Application

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(54) Title: AN AUTOMATED SYSTEM FOR TESTING ADAS FRAME WORK

(57) Abstract: According to an embodiment of the invention, a method 100 and system 200 for testing an Advanced Driver Assistance System (ADAS) framework is disclosed. The method 100 may include a step 102 of capturing a real environment data. The real environment data may have a plurality of objects such as pedestrians, vehicles, road, sky etc. The method 100 may further include a step 106 of annotating the plurality of objects in the captured real environment data. Once the plurality of objects is annotated, the annotated data may be stored in a data storage platform. The method 100 of testing the ADAS framework may further include a step 110 of analysing the stored annotated data by comparing the stored annotated data with a test data. The test data used for comparing may be the captured real environment data with modified environmental parameters.

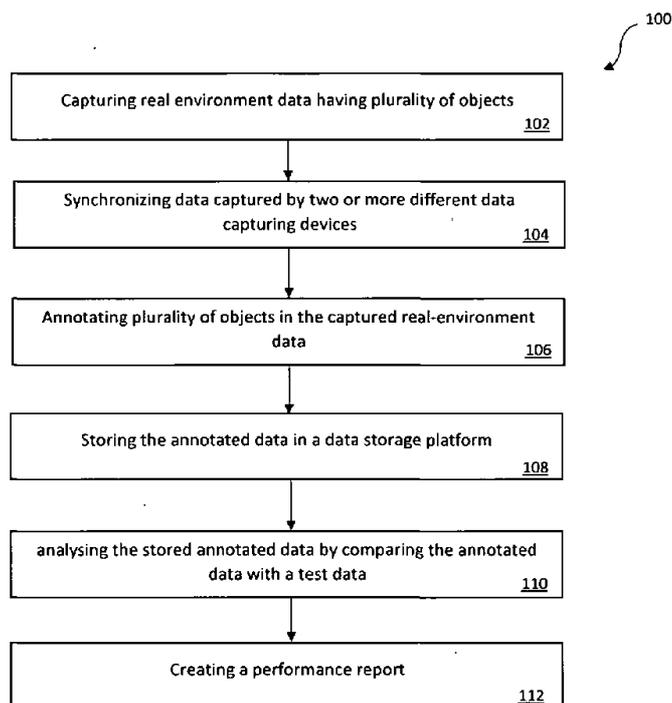


Figure 1

ABSTRACT



An Automated System for Testing ADAS Framework

According to an embodiment of the invention, a method 100 and system 200 for testing an Advanced Driver Assistance System (ADAS) framework is disclosed. The method 100 may include a step 102 of capturing a real environment data. The real environment data may have a plurality of objects such as pedestrians, vehicles, road, sky etc. The method 100 may further include a step 106 of annotating the plurality of objects in the captured real environment data. Once the plurality of objects is annotated, the annotated data may be stored in a data storage platform. The method 100 of testing the ADAS framework may further include a step 110 of analysing the stored annotated data by comparing the stored annotated data with a test data. The test data used for comparing may be the captured real environment data with modified environmental parameters.

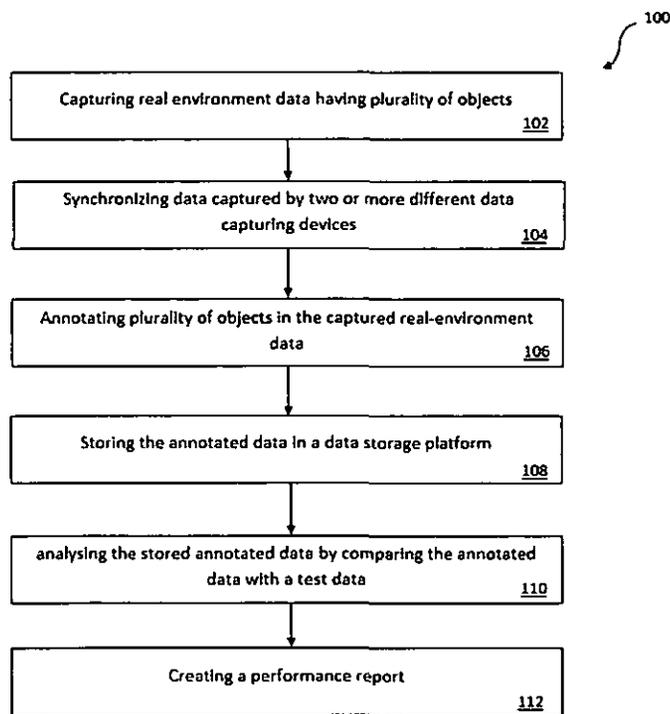


Figure 1

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28-Mar-2019/27374/201841011616/Abstract

We claim:



1. A method 100 of testing an Advanced Driver Assistance System (ADAS) framework, the method comprising:
  - capturing a real environment data having a plurality of objects;
  - annotating the plurality of objects in the captured real environment data;
  - storing the annotated data in a data storage platform; and
  - analysing the stored annotated data by comparing the stored annotated data with a test data, the test data being the captured real-environment data with modified environmental parameters.
  
2. The method 100 of testing the Advanced Driver Assistance System (ADAS) framework as claimed in claim 1, wherein the method of annotating the plurality of objects comprising:
  - inputting the captured real environment data into an annotating system; and
  - marking and labelling the plurality of objects in the captured real environment data.
  
3. The method 100 of testing the Advanced Driver Assistance System (ADAS) framework as claimed in claim 1, wherein the method of annotating the plurality of objects comprising:

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inputting the captured real environment data in a convolution neural network;

extracting features from each frame of the data by multiple convolution layers and pooling layers of the convolution neural network; and

classifying the objects based on the features extracted by the convolution neural network.

4. The method 100 of testing the Advanced Driver Assistance System (ADAS) framework as claimed in claim 3, wherein the method of annotating the plurality of objects may further include a training method, the training method comprising:

preparing training datasets from at least one or more annotated data;

combining the convolution and the pooling layers with extracted feature in the convolution network;

filtering the noise from the data after combining the convolution and pooling layers; and

augmenting the data to predict the plurality of objects in the data.

5. The method 100 of testing the Advanced Driver Assistance System (ADAS) framework as claimed in claim 1, wherein the method of annotating the plurality of objects comprising:

inputting the captured real environment data into an annotating system;

marking and labelling at least one or more objects of interest in a frame;

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annotating the one or more objects in subsequent frames related to the marked and labelled frame, wherein the method of annotating comprising:

inputting the captured real environment data with the marked and labelled frame in a convolution neural network;

extracting features from each subsequent frame of the data by multiple convolution layers and pooling layers of the convolution neural network; and

classifying the objects based on the features extracted by the convolution neural network.

6. The method 100 of testing the Advanced Driver Assistance System (ADAS) framework as claimed in claim 1, wherein the annotation includes two-dimensional (2D) annotation and three-dimensional (3D) annotation of the plurality of objects.
7. A system 200 for testing an Advanced Driver Assistance System (ADAS) framework, the system comprising:
  - a real environment data capturing device;
  - a processor for annotating a plurality of objects in the real environment data;
  - a data storage platform for storing the annotated data; and
  - a data analyser to compare the annotated data with a test data, the test data being a modified real environment data.
8. The system 200 for testing the Advanced Driver Assistance System (ADAS) framework as claimed in claim 7, wherein the real environment data capturing device

is a camera, a video recorder or a sensor.

9. The system 200 for testing the Advanced Driver Assistance System (ADAS) framework as claimed in claim 7, wherein the system further includes a synchronization module for synchronizing the real environment data captured by two or more data capturing devices.
  
10. The system 200 for testing the Advanced Driver Assistance System (ADAS) framework as claimed in claim 7, wherein the system further includes a library of different environmental parameters to modify the environment of the captured real environment data to produce a test data.

Dated this 28<sup>th</sup> day of March 2018

  
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## FIELD OF INVENTION



The invention generally relates to a field of Advanced Driver Assistance System and more particularly to a method and system for testing an Advanced Driver Assistance System framework and autonomous drive system.

## BACKGROUND

An Advanced Driver Assistance System (ADAS) aims to improve the comfort and safety of both the driver as well as the traffic participants. The Potential applications of such a system includes lane departure warning, collision warning, adaptive cruise control, intelligent speed control etc.

A typical ADAS includes a camera mounted on the dashboard of a vehicle. The camera captures videos of various objects surrounding the vehicle which are then processed in a processing unit for detecting objects such as vehicles, pedestrians, traffic signs etc. For validating an ADAS system, large miles of drive data are required. As per the European New Car Assessment Programme (EURO N-CAP) standards, level-2 needs around 2.5 million miles of drive data to validate the ADAS system. The verification and validation of these ADAS systems are important for the deployment of ADAS safety critical system. Furthermore, the assessing such a large data needs ground reference data to quantify the performance of such ADAS systems. The manual generation of ground truth data (reference data or expected results data) is a highly time-consuming process and requires loads of effort.

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Hence there is a need for an improved method and system for generating ground truth data and testing an Advanced Driver Assistance System framework.

## SUMMARY OF THE INVENTION

According to an embodiment of the invention, a method of testing an Advanced Driver Assistance System (ADAS) framework is disclosed. The method may include a step of capturing a real environment data. The real environment data may have a plurality of objects such as pedestrians, vehicles, road, sky etc. The method may further include a step of annotating the plurality of objects in the captured real environment data. Once the plurality of objects are annotated, the annotated data may be stored in a data storage platform. The method of testing the ADAS framework may further include a step of analysing the stored annotated data by comparing the stored annotated data with a test data. The test data used for comparing may be the captured real environment data with modified environmental parameters.

According to an embodiment of the invention, a system for testing the Advanced Driver Assistance System framework is disclosed. The system for testing the ADAS framework may include a real environment data capturing device. The real environment data capturing device may be a camera or a sensor. The system may further include a processor. The processor may annotate a plurality of objects in the real environment data. The system may further include the data storage platform wherein the annotated data may be stored. A data analyser in the system may compare the annotated data with the test data. The test data may be the real-environment data with modified environmental parameters.

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## **BRIEF DESCRIPTION OF DRAWINGS**

Other objects, features, and advantages of the invention will be apparent from the following description when read with reference to the accompanying drawings. In the drawings, wherein like reference numerals denote corresponding parts throughout the several views:

Figure 1 illustrates a flowchart of a method of testing an Advanced Driver Assistance System (ADAS) framework according to an exemplary embodiment of the invention.

Figure 2 illustrates a block diagram of a system for testing the ADAS framework according to an exemplary embodiment of the invention.

Figure 3 illustrates a block diagram of a processor for annotating a plurality of objects according to an exemplary embodiment of the invention.

## **DETAILED DESCRIPTION OF DRAWINGS**

The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of exemplary embodiments. It includes various specific details to assist in that understanding but these are to be regarded as merely exemplary. Accordingly, those of ordinary skilled in the art will recognize that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the invention. In addition, descriptions of well-known functions and constructions are omitted for clarity and conciseness.

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Figure 1 illustrates a flowchart of a method 100 of testing an Advanced Driver Assistance System (ADAS) framework according to an exemplary embodiment of the invention. The method 100 may be employed in ADAS and autonomous drive systems to analyse and generate a ground truth data as well as to determine the accuracy of the generated ground data. In method 100, a step 102 includes capturing a real environment data having a plurality of objects. The real environment data may be the surroundings of a vehicle that is capturing the data. The plurality of objects in the captured data may include traffic participants such as, but not limited to, vehicles, pedestrians, roads, traffic lights, sky, trees etc. It will be apparent to a person skilled in the art, the weather of the environment in the captured data may be cloudy, foggy, rainy, sunny etc. The data may be further captured at different time of the day such as in morning, evening, night etc. According to an embodiment, the real environment data may be an image. According to another embodiment, the real environment data may be a video. According to yet another embodiment, the real environment data may be in a format of a sensor data. It should be noted that the vehicle capturing the real environment data may include one or more data capturing devices to capture the real environment data from different positions and angles.

In step 104, the real environment data captured by one or more data capturing devices may be synchronized. The synchronization may be performed for achieving proper annotation of the plurality of the objects in the captured data. By way of an example if the real environment is captured by two different data capturing devices at the frame rate of 24 FPS and 30 FPS, the step 104 may synchronize the data from both the data capturing devices. It should be noted that the synchronization in step 104 may be required as per case to case basis and may not be required in cases where real environment data is captured by only one image capturing device

or where the data captured by multiple data capturing devices are in same frame rate.

In method 100, a step 106 includes annotating the plurality of objects in the captured real environment data. The annotation of the plurality of objects in the captured data may be achieved by any one of the three methods. The three methods of annotating the plurality of objects may include manual annotation, semi-automatic annotation and fully automatic annotation.

The manual method of annotation may include a user to manually mark and label each object of interest in each frame of the data. By way of an example, the user may manually annotate the pedestrian, vehicle, road etc in the captured data. In semi-automatic method of annotation, the user may manually mark and label the object of interest in a first frame of the data. Once manual annotation is performed in the first frame, the semi-automatic annotation method may perform the annotation of the subsequent frames automatically by a machine learning algorithm. The semi-automatic method may use interpolation and prediction techniques to identify the objects in the data. The fully automatic method may work on a deep learning algorithm. The deep learning algorithm for annotating the plurality of objects may include inputting the captured real environment data in a convolution neural network. In the convolution network, features from each subsequent frame may be extracted by convolution layers and pooling layers. Once the features are extracted, the objects are classified and annotated. The fully automatic method may further include a training method. The training method may prepare training datasets from the annotated data. The training method may combine the convolution and the pooling layers with extracted feature in the convolution network. After combination of layers, the data may be filtered and the noise is removed from the data. The data may be then augmented to predict the plurality of objects in the data. The

semi-automatic method and the fully automatic method may have a feature to perform the

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annotation by semantic segmentation. The semantic segmentation may recognize and understand each frame of the data in pixel level. The semi-automatic method and the fully automatic method may further have a feature of performing two-dimensional (2D) annotation and three-dimensional (3D) annotation of the plurality of objects. Once the annotation is achieved by any the methods, a ground truth data is generated. In the following, the terms 'ground truth data' and 'annotated data' may be used interchangeably without restricting the invention in any way.

In step 108, the method 100 may include storing the annotated data in a data storage platform. The annotated data may be stored in the data storage platform in form of a data structure and data volume. The data structure may enable the user to determine the number of times each object may occur in the data. By way of an example, the data structure may enable the user to determine that the data may include ten vehicles, five pedestrians, three traffic lights etc.

In step 110, the method 100 may include analysing the stored annotated data. The stored annotated data may be analysed by comparing the stored annotated data with a test data. The test data may be the captured real environment data modified with environmental parameters. For creating a test data, the real environment data may be send to a test framework. In the test framework, the real environment data may be modified with different environmental parameters stored in a library function. The different test data may enable the user to test the validity of the stored annotated data or ground truth data in different scenarios.

In step 112, a performance report is created. The comparison of the annotated data with the test data may enable in determining the precision and accuracy of the annotated data. The

performance report may further include a graphical representation of the comparison between the annotated data and the test data that may enable the user to understand the difference.

Figure 2 illustrates a block diagram of a system 200 for testing the ADAS framework according to an exemplary embodiment of the invention. The system 200 may include a real environment data capturing device 202 mounted on a vehicle. According to an embodiment, the real environment data capturing device 202 may be a camera. According to another embodiment, the real environment data capturing device 202 may be a sensor. The sensor mounted on the vehicle may include sensors such as, but not limited to, LIDAR, RADAR or any other suitable sensor known in the art. It should be noted that one or more data capturing devices 202 may be mounted on the vehicle to capture the real environment from different position and angles.

The system 200 for testing the ADAS framework may further include a processor 204. The processor 204 may process the data to annotate the plurality of objects in each frame of the data. The processor 204 may perform the annotation of the objects by any of the three methods. The method for annotating the object in the video may be manual annotation method, semi-automatic annotation method and fully automatic annotation method. The manual method of annotation may include a user to manually mark and label the object of interest in each frame of the data. By way of an example, the user may manually annotate the pedestrian, vehicle, road etc in the captured data. In semi-automatic method of annotation, the user may manually mark and label the object of interest in a first frame of the data. Once manual annotation is performed in the first frame, the semi-automatic method performs the annotation of the subsequent frames automatically by a machine learning algorithm. The fully automatic method may work on a deep learning algorithm. The deep learning algorithm for annotating the

plurality of objects may include inputting the captured real environment data in a convolution

neural network. In the convolution network, features from each subsequent frame may be extracted by convolution layers and pooling layers. Once the features are extracted, the objects are classified and annotated. It should be noted that the system 200 may be deployable either online or offline. The system 200 may be further capable of performing analytics with big data.

The system 200 may further include a data storage platform 206. The data storage platform 206 may be cloud storage. The data storage platform 206 may further include other forms of storage such as a hard drive or any other storage known in the art.

The system 200 may further include a data analyser 208. The data analyser 208 may analyse the stored annotated data by comparing the annotated data with a test data. The test data may be the captured real environment data modified with environmental parameters. For creating a test data, the real environment data may be send to a test framework 210. In the test framework, the real environment data may be modified with different environmental parameters stored in a library function 212. The test data may be stored in a data storage platform 214. The different test data may enable the user to test the validity of the stored annotated data or ground truth data in different scenarios.

Figure 3 illustrates a block diagram of a processor 204 for annotating a plurality of objects according to an exemplary embodiment of the invention. The processor 204 may include three modes 220 for annotating the plurality of objects. The annotation modes may be the manual mode, the semi-automatic mode and the fully automatic mode. The processor may further include a player 222 for controlling the playback of the data captured by the data capturing device 202. The user may play, stop, rewind, fast forward the data as well may directly go to a specific frame of the data as desired. The processor 204 may further include an inspection

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option 224. The inspection option 224 may allow the user to manually inspect the annotations in the data to perform corrections in the annotation done automatically by the processor 204. The inspection option 224 may enable the user to add, re-annotate and de-annotate the objects in the frames of the data. The processor 204 may further have an option 226 to configure the system to annotate only the desired type of objects from the list of objects in the data. The selective annotation may enable the user to ignore the objects unimportant in calculation of the ground truth data. By way of an example, if the user wants to annotate only vehicles in the data, the user may select vehicle option and may ignore the other objects in the data. On completing the annotation of the objects in the data, the processor 204 may enable the user to generate the ground truth data. The processor 204 may be constructed on a cloud system that may enable the data to be processed simultaneously in multiple devices thereby generating the ground truth data faster.

It is understood that the above description is intended to be illustrative, and not restrictive. It is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined in the appended claims. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein," respectively.

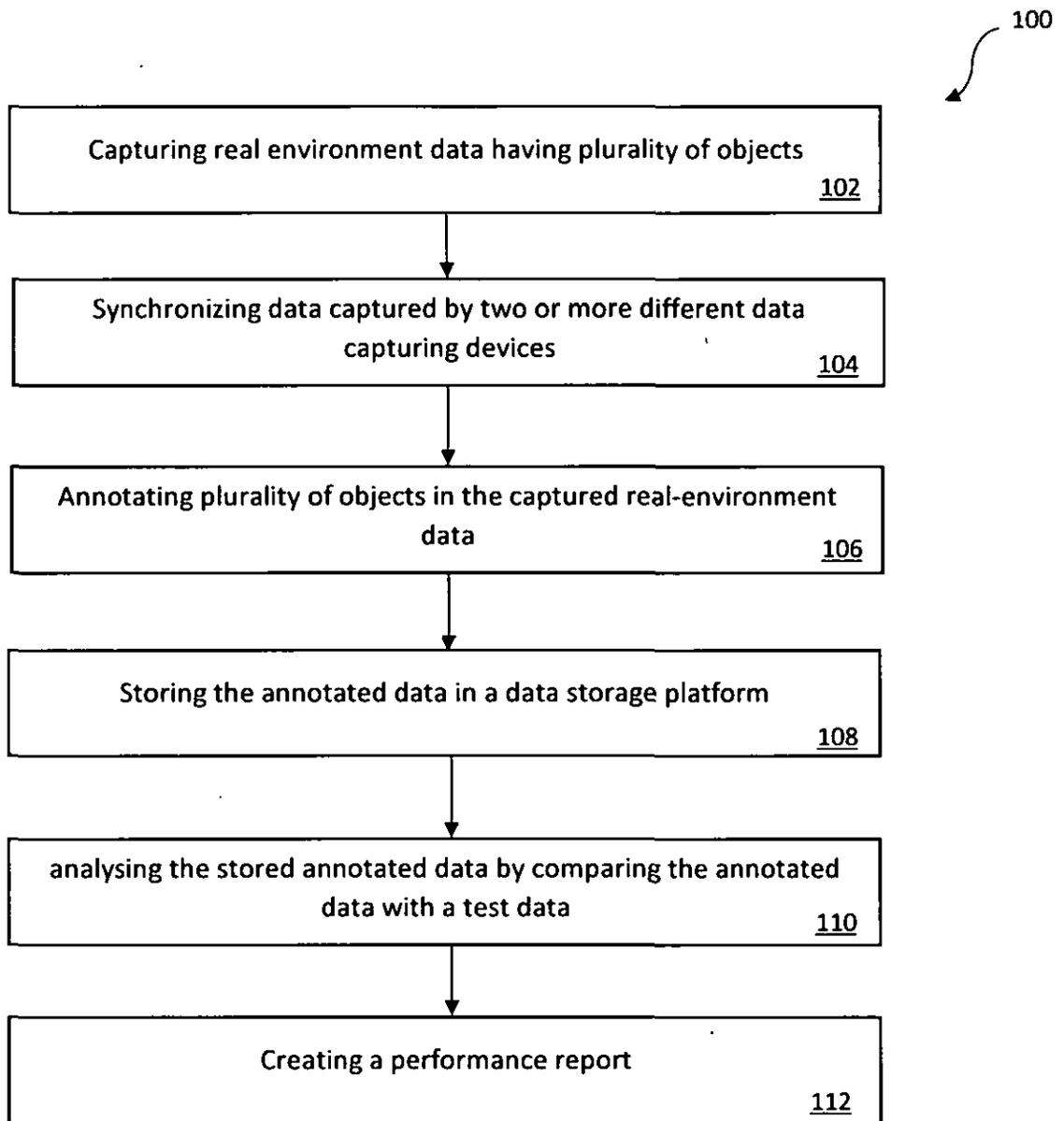
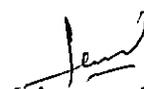


Figure 1

  
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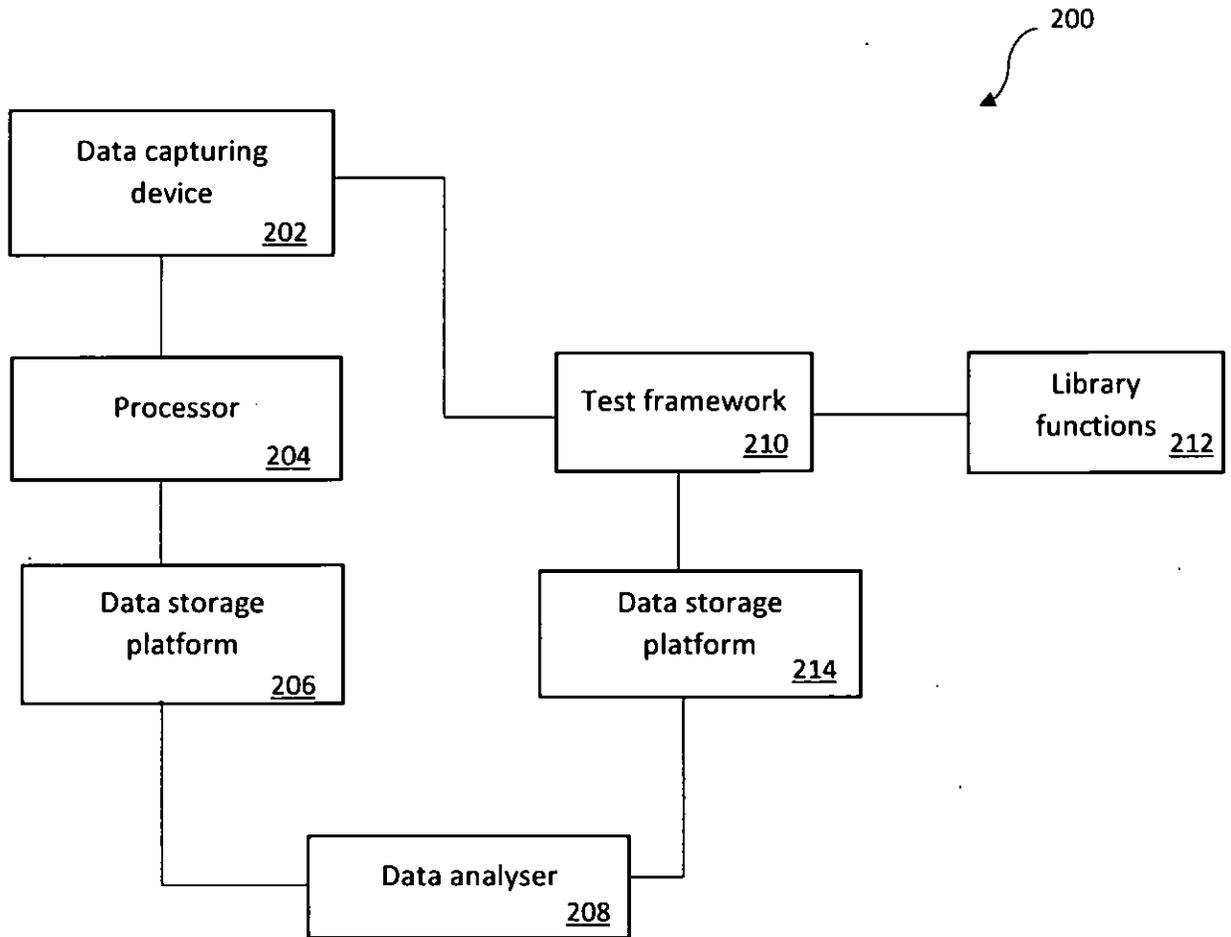


Figure 2

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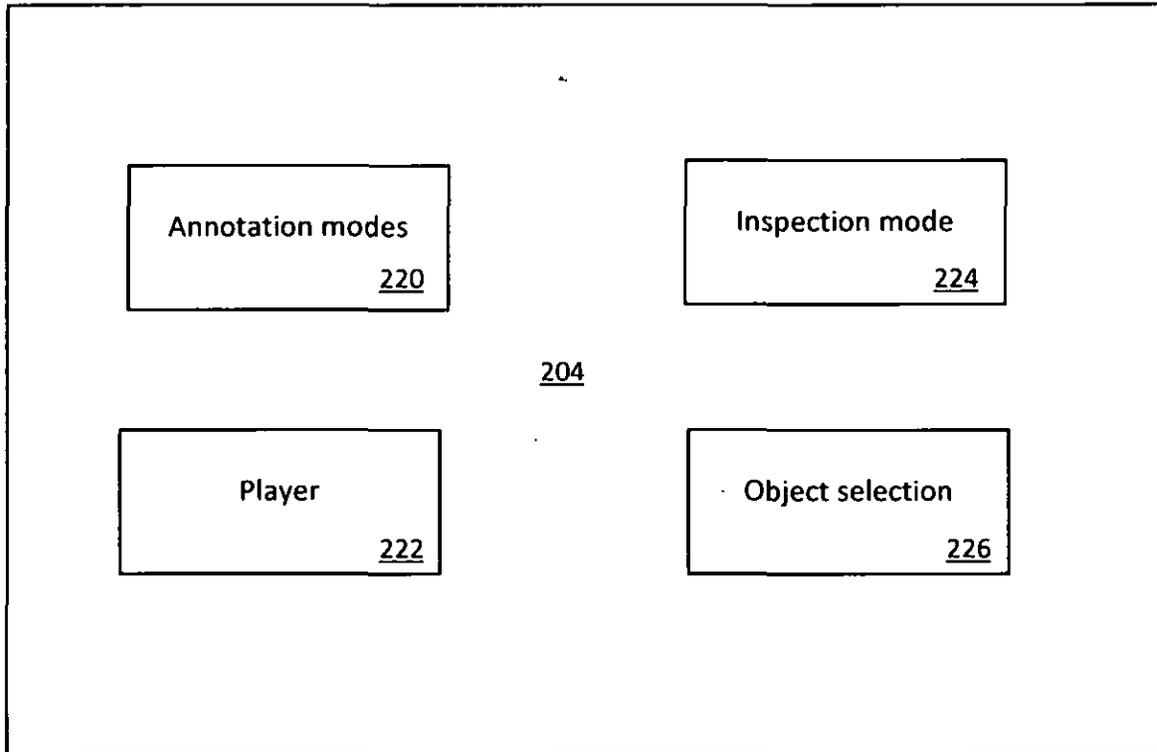
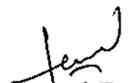


Figure 3

  
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