Sony Depthsensing Solutions response to NHTSA Request for Information: Impaired Driving Technologies

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[1] INTRODUCTION

a. NHTSA RFI Impaired Driving Technologies

NHTSA released below stated request. Sony is answering the questions in this document.

Request for Information: This notice requests information to inform NHTSA about the capabilities, limitations, and maturity of currently available technologies or those under advanced stages of development that target impaired driving. The Joint Explanatory Statement accompanying the Further Consolidated Appropriations Act, 2020, Public Law 116-94 (2020), requires NHTSA to facilitate the sharing of this information and the implementation and integration of impaired driving technology across the automotive industry. NHTSA plans to conduct further research on such technologies. To ensure a comprehensive review of these technologies, NHTSA requests interested parties to submit information to the Agency on related technologies that are being researched, developed, or marketed. More specifically, NHTSA seeks information about technologies that can detect degrees of driver impairment through a range of approaches including

1. *technologies that can monitor driver action, activity, behavior, or responses, such as vehicle movements during lane keeping, erratic control, or sudden maneuvers;*
2. *technologies that can directly monitor driver impairment (e.g., breath, touch-based detection through skin);*
3. *technologies that can monitor a driver's physical characteristics, such as eye tracking or other measures of impairment; and*
4. *technologies or sensors that aim direct measurement of a driver's physiological indicators that are already linked to forms of impaired driving (e.g., BAC level for alcohol-impaired driving).*

NHTSA is interested in information about product specifications; impairment measurement metrics, methods, and systems; impairment classification approaches and capabilities; availability of test results and data that support system capabilities and limitations; advanced sensors; and other technologies that could be used in a vehicle to detect impaired drivers.

Input is also requested about whether and how systems have been validated to date, including human factors issues and user acceptance of proposed approaches. Further, NHTSA requests information on the range of active intervention these technologies are targeted to support in vehicles based on the type and level of impairment estimated, or measured, by the system with respect to the system's confidence in such assessment.

Responses most useful to NHTSA would include specific information about the product capabilities and limitations, the state of its development, its availability and/or current uses. Examples of useful information include vendor contact information; information related to product's marketed capabilities; a description of the approach the technology uses to detect, estimate, or measure driver impairment; product specifications, including physical dimensions, accuracy, tolerance limits, performance characteristics such as temperature limitations, vehicle integration feasibility, and part-life in the *automotive environment; closest Technology Readiness Level (TRL) of the technology based on best practices described in the General Accounting Office Technology Readiness Assessment Guide (https://www.gao.gov/assets/710/703694.pdf); any publicly shareable information related to the cost ranges for the unit, its installation, as well as lifetime maintenance; any data related to studies that targeted usability and user acceptance; known technology defeat strategies users may employ; and impairment detection and impairment differentiation capabilities (alcohol-impaired, drug-impaired, distracted, drowsy, etc.), including false-positive and false-negative detection rates. Additionally, NHTSA would like to know how existing technologies have been evaluated in laboratory or field tests or in operational deployments and how positive impairment data was utilized in those studies.*

NHTSA encourages commenters to provide information in common file Start Printed Page 71989formats, such as Microsoft Word, pdf, or plain text and limit responses to no more than 10 pages, not including appendices.

b. Sony Answers

In the following document Sony will respond to the NHTSA RFI topic:

(1) technologies that can monitor driver action, activity, behavior, or responses, such as vehicle movements during lane keeping, erratic control, or sudden maneuvers;

c. Terms, Abbreviations and Definitions

Term or Abbreviation	*Definition*
EDR	Event Data Recorder
GDPR	General Data Protection Regulation
iToF	Indirect Time-of-Flight
SDS	Sony Depthsensing Solutions

[2] SONY REPLY TO NHTSA

(1) Technologies that can monitor driver action, activity, behavior, or responses, such as vehicle movements during lane keeping, erratic control, or sudden maneuvers;

The Sony indirect Time-of-Flight sensing technologies have the advantage of providing reliable depth and infra-red reflection data out of one sensor. Together, with novel algorithms the complete solution provides advanced functionalities for driver, occupant and complete In-Cabin monitoring.

The depth information provides a reliable geometric 3D point cloud of the driver/ occupant/ In-Cabin to be used to map to the body, head, arms, etc. and accurately track the occupants pose and movements. The point cloud is a 3D image, based on the iToF sensors precise depth information. The iToF sensing enables efficient registration of the different subtle body movements in high resolution in time domain of minimum 60 fps. Due to the fast 3D point cloud acquisition and its mapping, the system offers real-time driver activity and In-Cabin monitoring.
Based on the high resolution and fast detection of body and head, the system enables recognition of the driver behavior and is the ideal solution for:

a) non-driving related activities detection: phone usage, smoking, eating, drinking and

b) driving related activities detection: driving behavior (e.g., hands on wheel) and HMI interaction that can indicate the level of driver attentiveness; See example of the point cloud and the explanatory features in Fig. 1.

Moreover, the real-time system also provides the possibility of assessing the driver responsiveness in sudden situations, such as accidents, which can be recorded and stored in the non-personal GDPR form within the future EDR systems.

Figure 1: Sony DS the driver monitoring system providing the body size/shape and detailed joint position and full body skeleton in 3D.

Apart from geometrical 3D body feature registration and tracking, the system also detects and monitors the area around the driver, objects that the driver interacts with and the co-passenger. The camera sensors can be used with wide angle lenses, which provide large field of view for the In-Cabin, or as well narrow-angle lenses to focus on certain areas in the In-Cabin.

In Fig.2 and Fig. 3, is shown an example of the iToF reflection image (confidence) and the 3D point cloud of the driver. For a defined camera position two different driver activity cases are detected: phone usage and calling. The camera position is adaptable on request of customers or regulations to monitor within the optimal field of view.

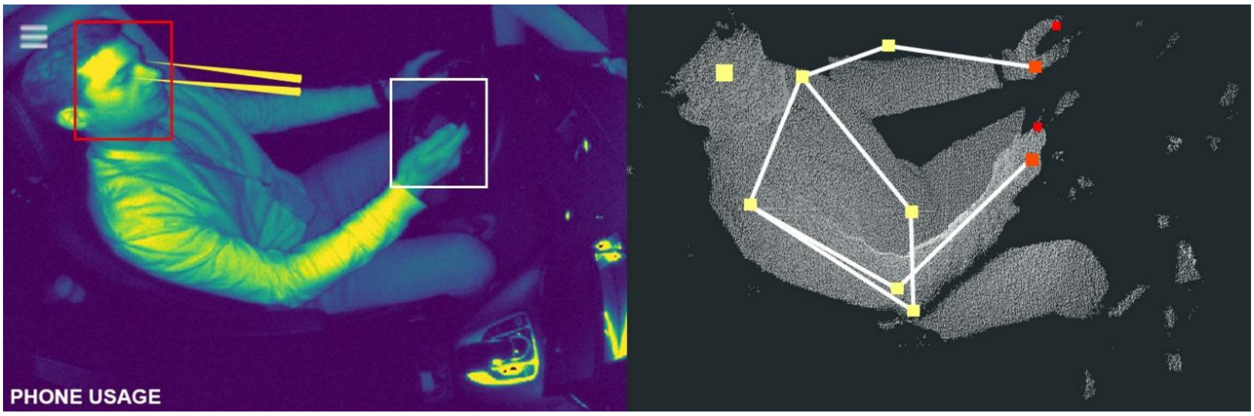

Figure 2: Roof module camera position with reflection image (left) and point cloud of the driver with body skeleton. Activity of the driver activity – phone usage.

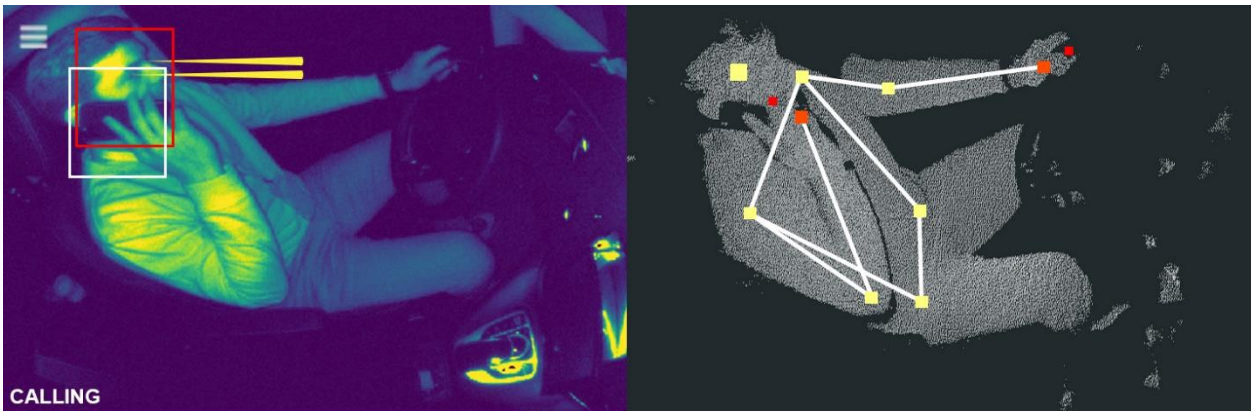

Figure 3 Roof module camera position with reflection image (left) and point cloud of the driver with body skeleton. Activity of the driver activity – calling.

In Fig. 2 and Fig. 3, the system field of view includes the entire driver's body (including head and face) and the surrounding area. Using this concept, the surrounding objects, the driver hands, and the facial features are monitored at the same time. This enables to distinguish more clearly between different driver activities and types of behavior, such as differentiation between the

a) time sharing - phone usage/ distraction and the
b) driving tasks – focus on the road (eye head pose and gaze towards the windshield)

as shown in the example in Fig. 2. Specifically, like in this example, if monitoring only head and facial features, it could be concluded that the driver is focusing on the driving tasks, as the gaze direction is front facing, towards the street, without showing time sharing and inattentiveness. However, if the head/face monitoring is combined with the full body postures, surrounding monitoring and phone detection, it is clearly detected as time sharing phone usage, with all the related dangers that the inattentiveness could cause.

The 3D depth sensing technology provides a 2D infra-red image (grey-scale content independent of the day/ night illumination conditions) in addition to the depth and 3D point cloud information. This additional signal, in combination with depth information, enables facial feature recognition tasks, related to eye state, gaze, emotions, etc. The current spatial resolution for the depth and reflectance images is VGA 640x480, a higher resolution sensor is planned to be released in future.

The depth information provides a 3D point cloud of the driver's head/ body/ environment which is used for efficient head pose detection and efficiently mapping the driver's 3D head model, hence automatically providing facial key points to be tracked and analyzed using grey-scale information. For example, eye and mouth detection and tracking. Therefore, the system can easily adapt to different head and face types and provide accurate head orientation and positions of the key facial features. Using such key features, the system extracts the facial regions of interest from the grey-scale confidence images and analyzes them to obtain higher level features, such as eye open-close, eye gaze, and more.

In Fig. 4 the eye, gaze and face state is shown, which in combination with other depth related features (body and head pose), are computed to extract higher level features such as drowsiness, microsleep, sleep, distraction (long and short) detection, emotion estimation or sudden sickness detection, as possibly required by the upcoming by NCAP and regulation requirements.

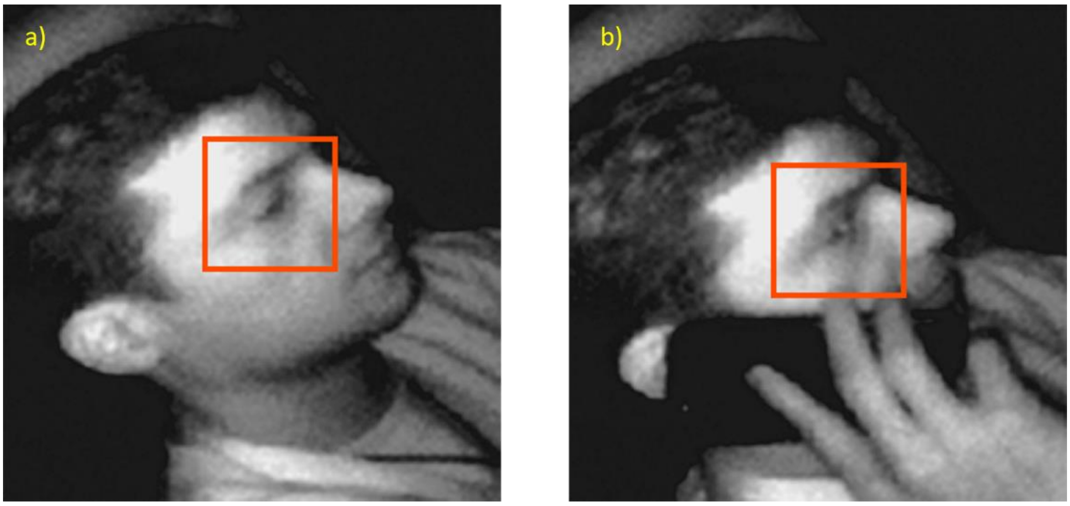

Figure 4: Head and eye related to (a) case in Fig. 2 and (b) case in Fig. 3, respectively.

SONY

In Fig. 5, is shown a snapshot of the Sony demo application with eye feature monitoring. The face/eye features are monitored at the same time with the body features, to detect the level of drive attentiveness regarding driver state.

Figure 5: Example of the drowsiness monitoring with face/eye feature tracking.

With the features shown in Table 1, the level of drowsiness, microsleep, sleep, level of the distraction, and sudden sickness can be determined. Depending on the requirement and application, different features, can be combined to reach certain functionality (for example drowsiness) with a related specified level of precision and reliability. As well a required end functionality (e.g., drowsiness) can be re-tracked vice versa, to define feature contribution for a necessary minimum accuracy. A minimum sensor specification can be defined. As well it is possible to tune and optimize the algorithms to reach the required feature accuracy.

Functions (status to be detected)	Description (indication via)
Drowsiness	Head nodding - uncontrolled head/body movements, eyelids closing slowly, blinking.
Microsleep	Slowed reflex/ body movement, frequent head nodding, prolonged eyelid closures (4 seconds or more)
Sleep	Eyes closed, head down, head back, using head/body pose
Distraction	Eyes away from the road and driving task, seating position, hands position
Sudden sickness	Eyes closed, head down, head back. using head/body pose

Table 1: Feature functions and description.