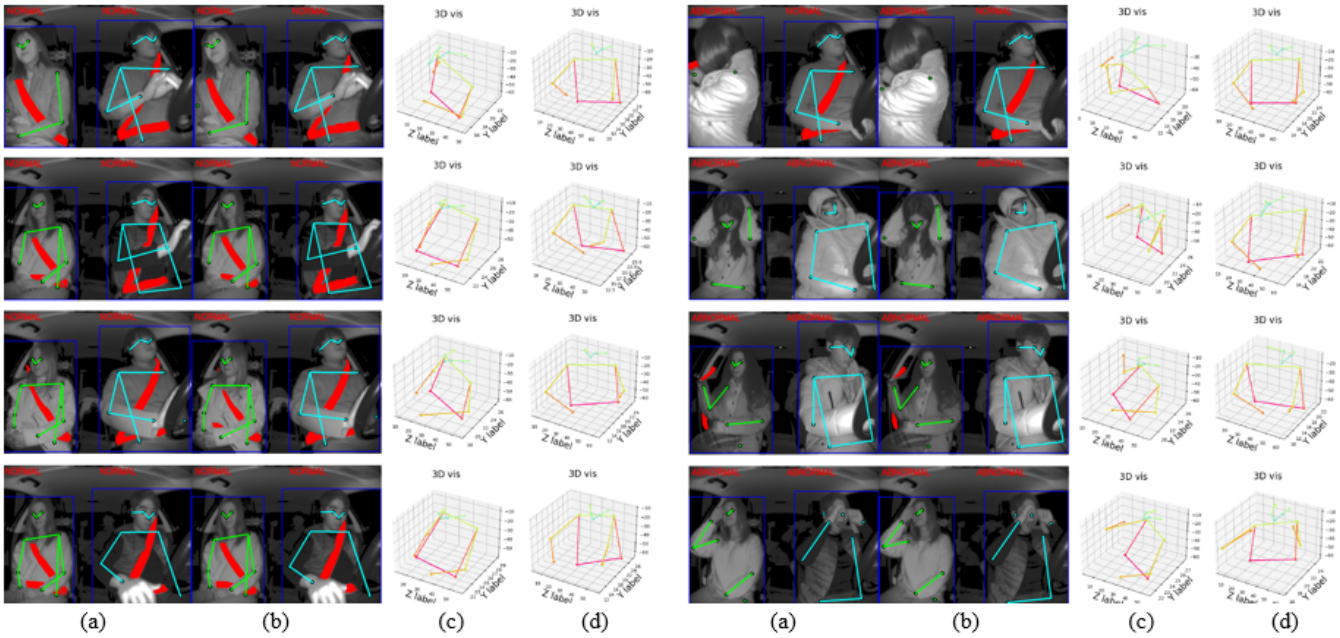

Figure 5: Estimated 3D human pose and seat-belt segmentation sample results. (a) ground truth, (b) estimated results, (c) 3D human pose estimation results of the passenger in the 3D domain, and (d) 3D human pose estimation results of the driver in 3D the domain.

mm; it shows better performance than state-of-the-art networks have achieved in public datasets. These results prove that our proposed network is sufficiently effective to be applied directly in in-vehicle environments.

As summarized in Table **??**, we evaluated the overall network performance. As mentioned above, the 3D pose estimation performance shows an MPJPE of 41.01 mm, and the 3D pose estimation network operates at 145.07 fps. Seat-belt segmentation also has a high IoU performance of 80.64% and 686.54 fps in a single operation. Finally, the seat-belt classification shows high accuracy of 95.90%. The operation speed of the entire network is 129.03 fps using an NVIDIA 3090 RTX. As described in Figure **??**, the qualitative results of our proposed network show remarkable performance. Our method implements seat-belt segmentation precisely even when little of the seat-belt is visible. The human pose reconstructed in 3D implies that our method could be applied to detect abnormal postures in vehicles. This proves that our proposed network is efficient at constructing a 3D human pose in in-vehicle conditions.

5 Conclusion

We proposed a novel method for an in-vehicle monitoring system for drivers and passengers. We first suggested an efficient methodology to manufacture an in-vehicle-aware dataset. Many conditions of in-vehicle environments were limited in terms of the area, number, and size of human objects and the movement of humans. Therefore producing datasets that consider these limitations can lower the annotation cost. We demonstrated the effectiveness of our method by applying it to our proposed network, which is a novel integrated framework that uses the 3D human pose estimation, seat-belt segmentation, and seat-belt status classification. Moreover, those tasks can be trained in an end-to-end manner. We believe that this study provides a novel solution for the in-vehicle monitoring of advanced driver assistance systems and thus enhances the safety for humans. Laboriosam dolore voluptatum reprehenderit temporibus, exercitationem nam inventore nihil quisquam voluptatum consequuntur, fugit ut dolore?Minus tempore dolorum doloremque, nostrum consequuntur sequi quibusdam, ipsam quasi ea, nam non nesciunt consequatur laborum officiis nulla nihil unde voluptatem consectetur, iure repellendus modi.Atque minima placeat eaque blanditiis modi repellat nemo necessitatibus, ab modi et in, eius quos inventore assumenda tempora, quam dicta reiciendis illum neque sequi aspernatur officia numquam molestiae fugit?Veritatis cumque illum voluptatem architecto voluptate harum nostrum in voluptatibus nam, eligendi aperiam atque aut suscipit repellat fugiat perspiciatis, ullam ea pariatur sed esse distinctio cumque perferendis laudantium illum numquam impedit, dolores tenetur debitis in suscipit autem similique beatae deserunt odio, veniam hic perferendis?Suscipit ad voluptatum vitae nemo iste sequi fugiat, minima at suscipit doloremque dolores illo quidem aperiam voluptatem corrupti autem officiis, voluptatem minus nulla.Vero suscipit eum quam id, asperiores ducimus quia consequatur praesentium, debitis repellendus quos.Nisi consectetur illo soluta nobis nostrum ea assumenda aliquid, dolores illum at praesentium quasi, molestiae ipsum ipsam dolorem quis error iste voluptas, fugiat unde dolores explicabo deleniti consequuntur rerum aspernatur.Nobis minima recusandae re-

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