Some Results Of The Paper: Panoramic Video Delivery Based on Laplace Compensation and Sphere-Markov Probability Model

Fig. 1 demonstrates that for the sequence *rollercoaster*, the model of Laplace compensation is always the best way to predict the users' motion when RTT is below 430ms, which is true in most cases. If RTT is larger than 430ms, Sphere-Markov model should be exploited to keep high-quality performance. We use $RTT_{threshold} = 430\text{ms}$ to represent the intersection point of the two models. To supply high-quality experience to users, a server should adopt this strategy: RTT between the server and a client should be measured first. If RTT is below $RTT_{threshold}$, the server should take the model of Laplace compensation, and quality value can be increased at least 3.33%, at most 60.6% compared to the model without prediction; otherwise, the server ought to use Sphere-Markov probability model to estimate users' motion and then transmit corresponding streams, and the quality value could be increased at least 49.8%, at most 137% compared to the model without prediction. Of course, different sequences have different $RTT_{threshold}$, which will be demonstrated in our experiments. Furthermore, for the sequence *rollercoaster*, the model of constant angular velocity increases the quality value only 37.7% at most and the model of constant acceleration always performs even worse than it. We also notice that quality value of the naïve model (with no prediction) picks up at around 500ms, which is due to the fact that most of users of *rollercoaster* are inclined to reciprocate during their watching the video. Probably Every $T = 500\sim700\text{ms}$, they move back to a viewpoint which is close to the one they reached T (ms) before, which causes the naïve model and Sphere-Markov probability model to rise again at around T (ms).

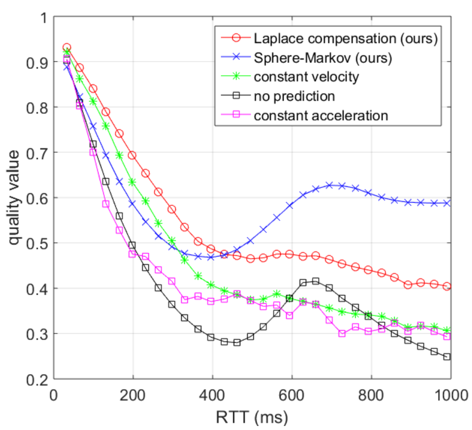

Fig. 1. Sequence ***rollercoaster***. Quality values of the models of Laplace Compensation, Sphere-Markov Probability, constant velocity, no prediction, constant acceleration. By Laplace Compensation, quality value can be increased at least 3.33%, at most 60.6% compared to the model without prediction; above 430ms, by Sphere-Markov, the quality value could be increased at least 49.8%, at most 137% compared to the model without prediction.

Fig. 2 shows the bit rate performance of the models. As mentioned in Part A of this section, transmitting the whole frame consumes a bandwidth of 20Mbps, which will cause too much burden. From Fig. 2 we can see that bit rate of the Laplace-compensating model is at least 4.3Mbps (save 78.7%) and converges to around 5.6Mbps (save 72.2%); bit rate of Sphere-Markov probability model is nearly in proportion to RTT, which indicates that if we would like to obtain high-quality QoE when RTT is large, more bandwidth must be consumed, which is reasonable because larger area of the panoramic video should be transmitted in high-quality mode to ensure users' experience.

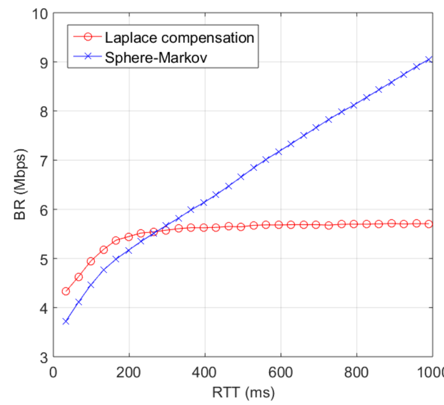

Fig. 2. Sequence ***rollercoaster***. Bit rate of the models of Laplace Compensation, Sphere-Markov Probability. Transmitting the whole frame consumes a bandwidth of **20Mbps**. Bit rate of the Laplace-compensating model is at least 4.3Mbps (save 78.7%) and converges to around 5.6Mbps (save 72.2%); bit rate of Sphere-Markov probability model is nearly in proportion to RTT.

Results of other sequences are similar to *rollercoaster*. For example, Fig. 3 shows results of *Dance1*. The model of constant acceleration always works no better than the model of constant velocity, so its results will not be shown. We could see that $RTT_{threshold} = 400\text{ms}$. Below 400ms, Laplace Compensation could increase quality value by at least 2%, at most 49.6%; above 400ms, Sphere-Markov model could increase quality value by at least 23.3%, at most 61.3%. Results of bit rate in Fig. 4 are similar to Fig. 2.

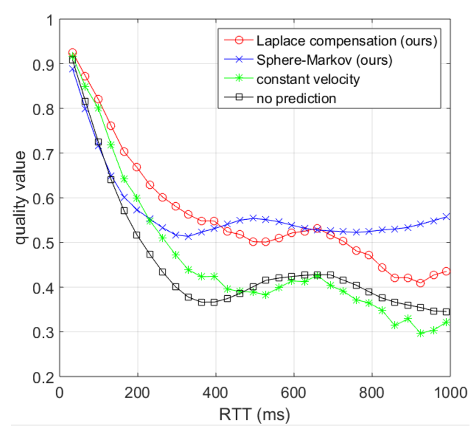

Fig. 3. Sequence ***Dance1***. Different models' quality values.

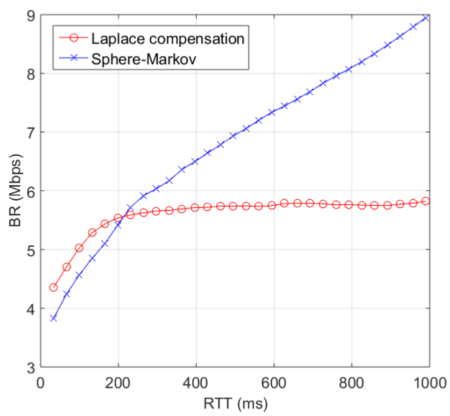

Fig. 4. Sequence ***Dance1***. Different models' bit rate.

Another example, Fig. 5 and Fig. 6 are results of sequence *Green Island*. $RTT_{threshold} = 220$ms. Below 220ms, Laplace Compensation could increase quality value by at least 3%, at most 7.4%; above 220ms, Sphere-Markov model could increase quality value by at least 4.3%, at most 66.2%.

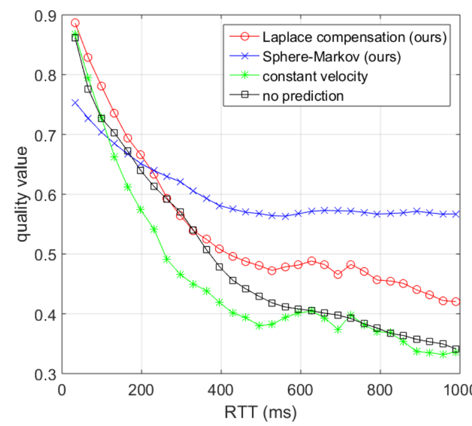

Fig. 5. Sequence ***Green Island***. Different models' quality values.

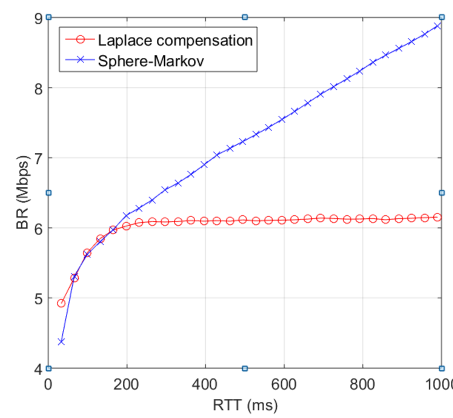

Fig. 6. Sequence ***Green Island***. Different models' bit rate.