





### 3. PSNR CURVES

Selecting a specific spatial resolution and bitrate combination to transmit video on MobileASL is important because there are tradeoffs with computational complexity, video quality, and resource availability on a cell phone such as battery life and data rate consumption. Larger video resolutions and higher bitrates result in higher video quality at the expense of increased computational power to transmit the data in real time. Before we can investigate how resource allocation is affected by video transmission, we need to determine at which bitrates and spatial resolutions we can get high enough video quality for intelligible conversations.

Despite the fact that PSNR may not be suitable for measuring subjective video quality, it still is a reasonable measurement of video quality when used across the same content [25]. We calculated PSNR of two different spatial resolutions (192×140 and 320×240 pixels) and 15 bitrates (10-150 kbps in increments of 10 kbps) of the same ASL video. The smaller spatial resolution was transmitted at 192×140 pixels and then enlarged and displayed at 320×240 pixels using bilinear interpolation [27] before PSNR was calculated.

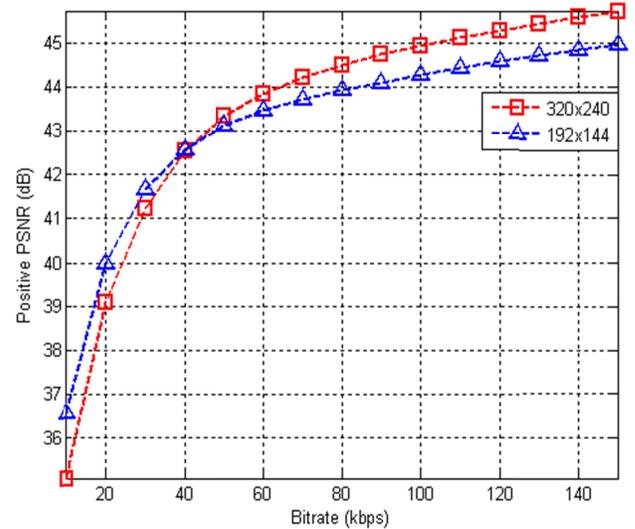
The same 12-second video clip of a local deaf woman signing at her natural signing pace with a stationary background was used in the calculation of PSNR. The video was recorded at 320×240 pixels at 15 fps. Duplicate videos were created at the smaller spatial resolution before calculating the PSNR. The x264 codec, an open source version of H.264 codec, was used to compress the videos at each spatial resolution and bitrate combination [3,24]. As Figure 2 demonstrates, the PSNR values for each spatial resolution increase monotonically with increasing bitrate.

We found that the PSNR curves demonstrated a crossover point where, at lower bitrates (40 kbps and below), the smaller spatial resolutions had higher PSNR values than the larger spatial resolution. Visual inspection of the same ASL video (displayed at the same size) transmitted at lower bitrates (10-40 kbps) showed more blocky artifacts in videos sent at 320×240 pixels than at 192×144. The crossover in the PSNR plots occurred because at very low bitrates, the higher resolution video is quantized more heavily and thus has very poor visual quality (such as blockiness and loss of fine details). The same videos at lower spatial resolutions are not quantized as heavily which results in higher measured video quality. As bitrates increase, the higher resolution has higher measured video quality than the smaller spatial resolutions. This is due to blurriness from enlarging the video. The crossover of PSNR curves has been found in other video compression techniques [16,19,29], but the results, to our knowledge, have not been used to evaluate human comprehension, which, along with subjective quality measures, is the focus of our online survey.

### 4. ONLINE SURVEY METHOD

From a technological perspective, transmitting video at the smaller spatial resolution and at the lowest bitrates takes the least amount of computational power and resources; however, without feedback from users, we cannot confirm that sign language communication with this video is intelligible.

We created and deployed a national three-part online survey to investigate user preferences and comprehension when varying the bitrates (10-60 kbps in increments of 10 kbps) and spatial resolutions (192×144 and 320×240) of ASL video. We did not consider bitrates higher than 60 kbps since the larger spatial



**Figure 2: PSNR(dB) vs. Bitrate (kbps) for spatial resolutions displayed at 320×240 pixels. Higher PSNR means higher objective video quality. Whether it means higher subjective perception of quality is a topic of this research.**

resolution always had higher video quality than the smaller spatial resolution.

The online survey began by asking participants to self-report their fluency in ASL. The survey asked different questions depending on the response to this question. Part 1 was a paired-comparison experiment which investigated the subjective video quality preferences of ASL speakers and non-ASL speakers (see Figure 3). Part 2 was a single-stimulus experiment which examined comprehension of ASL video of varying bitrates and spatial resolutions (ASL speakers only) (see Figures 4 and 5). Finally, part 3 asked demographic questions.

To determine how subjective video quality preference differs between ASL speakers and non-ASL speakers, it was important to get an equal number of ASL and non-ASL speaking respondents. We selected an online survey over a laboratory study because an online survey is accessible to most people with Internet access, so more respondents could be included from across the nation.

#### 4.1 Videos Used in Online Survey

##### 4.1.1 Videos in Part 1

The same 12-second video clips used to measure PSNR (see section 3, above) of ASL video were used in part 1 of the survey. A 12-second video duration was used because it was long enough for respondents to make a video preference selection while keeping the overall survey manageable to complete in 4-7 minutes. Recall that all videos were transmitted at their respective spatial resolution (192×144 and 320×240) at varied bitrates, and then displayed at 320×240 pixels (with the smaller spatial resolution enlarged using bilinear interpolation).

##### 4.1.2 Videos in Part 2

Twelve different video clips of the same local deaf woman signing different short stories at her natural signing pace were used.









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