# Optical mixing of PAL and VGA images using iGlasses AR helmet

W.Pasman, 6/2/2001

## Introduction

In my previous report I discussed the realtime behaviour of electronic mixers capable of mixing a PAL with a VGA image, downconverting the mixed images to PAL format. We concluded that the behaviour, especially in the temporal domain, is suboptimal. If possible, we would like get better real-time behaviour. One possibility is to mix these images optically. This report discusses how this can be done using the VGA LCD display in our AR helmet.
First, the setup is described. In the second section the mixing results are discussed. The third section discusses the latency as estimated from measurements. Results show that this is a feasible solution, but that the brightness of the mixed output is very low.

## The setup

We want to mix a PAL input signal with a 60 Hz VGA input signal, and the result should be a PAL output signal.
When mixing optically, a number of criteria have to be fulfilled. First, we have to record the mixed result with a camera. In order to avoid stripes to appear in the image, the camera has to fulfill two requirements:
(1) It can record in sync with the PAL input, so that it starts recording a field at the same time the display of a fields starts.
(2) The shutter speed can be exactly to the field length. If not, part of the frame may become darker because it is not yet exposed, or stripes may appear because part of the frame has been exposed twice.

If we would display the VGA input signal on a normal CRT monitor, we would get stripes in the VGA image. This is because the VGA runs somewhat faster than the PAL signal, and therefore a small part of the PAL image will be exposed double.  To avoid this brightness problem, we can use an LCD screen, where all pixels are always exposed an equal amount of time. As we have such LCD screens in our AR helmet, this should work out right.

Figure 1 shows the setup we made. PAL monitor 1 is a Sony Trinitron color TV, model KV-M1450D. The AR helmet is an iGlasses Protec. The PAL camera is a Toshiba 3CCD camera with Fujinon 1:2.2/4mm TF4DA-8 FOR 3CCD LENS (Figure 2). The PAL output signal was recorded on a JVC HR-DVS2 DV deck.

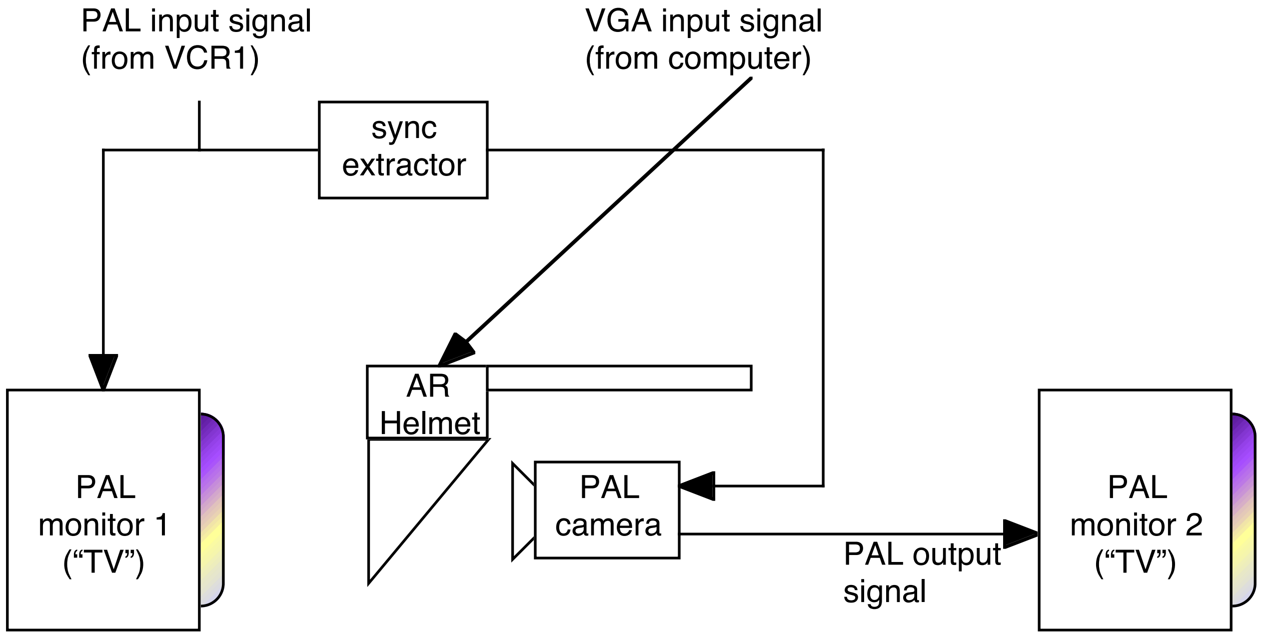


Figure 1. Test setup for optical AR mixing.


Figure 2.  Toshiba PAL camera used.

# Mixing results

We recorded the PAL output signal on a VCR, so that we could check the results. First, we tested without the AR helmet in place, to check the synchronisation issues. The synchronisation was running all right, the images were good (Figure 2). However, the lens of the camera gives a huge barrel distortion, maybe aggrevated by the slightly curved screen and the short distance between camera and screen. Furthermore, the images look slightly blueish.


Figure 2. Capture from the PAL monitor, without the AR helmet.

Next, we placed the AR helmet in place, to mix the VGA and PAL signals. We used a stable PAL signal using the VGA output on my laptop. Figure 3 shows the result. The glasses are so dark and the brightness of the PAL monitor so low that the PAL input is hardly visible. Figure 4 shows the same image, but with largely increased brightness.

Figure 3. Mixed result.

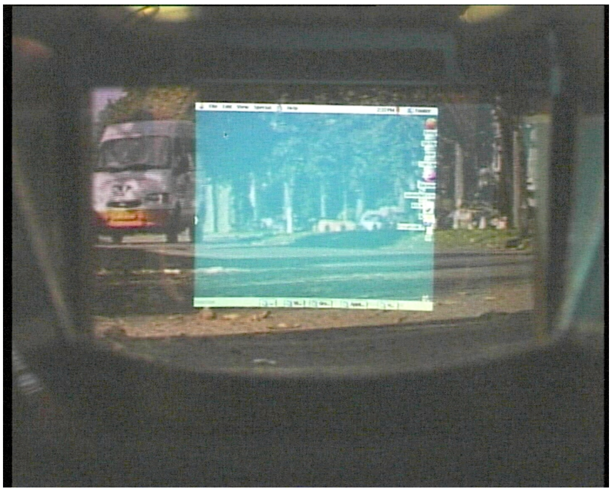

Figure 4. As Figure 3 but with largely increased brightness.

In Figure 4 it can be seen that the PAL signal is displayed very small. The resampling apparently goes very well: no artefacts are visible. The helmet is already very close to the camera, so we can not increase the size of the image this way. The problem should be solved by using another lens, which we do not have available for this camera.

# Latency

We attempted to measure the real end-to-end latency between the VGA input and output signal. To do this we tried to measure the light intensity behind the LCD display with a light sensitive transistor (which showed broken) and with a light sensitive resistor. Unfortunately the mechanical construction of the helmet is such that we can not measure directly behind the LCD panel, and the light intensity at the eye piece showed too low to measure with the light sensitive resistor.

Instead we checked the databooks about the chips involved. The system is based on Sony chips: two CXA1819Q RGB drivers (one for the left and one for the right eye), a single CXD2412Q timing generator [Sony01c] and two LCX007AL LCDs. These LCDs havea screen size of 3.4cm, a 200:1 contrast ratio with 5% optical transmittance and a resolution of 1068.5x480 (16:9) or 799.5x480 (4:3).
I could only find a japanese site with specs of the LCX007AL [Sony01e], but datasheets of similar LCDs in the same series, such as the LCX012 and LCX016 [Sony01c], show a similar simple shift register structure. Therefore the latency of the LCD must be negligible.
The RGB drivers are pretty simple as well [Sony01d]: they just do some color balancing and amplification. Therefore their latency must be low as well. Measurements on this chip show that this is indeed the case (Figure 5).
As the LCX007 and CXA1819Q the only two chips in the main signal line, the total latency must be roughly the sum of the two latencies. Concluding, the latency of the display should be negligible.

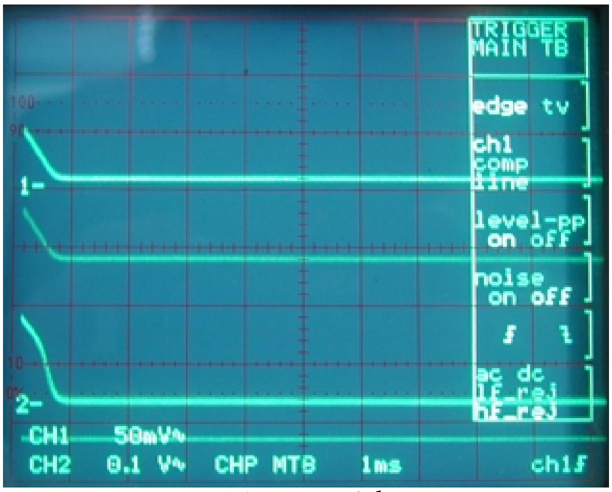

Figure 5. Measured latency of the CXA1819X RGB driver.

# Conclusion

Optical mixing seems to solve the resampling problems we had with the electronic video mixers. However, the wide angle lens on our camera introduces new problems: dark images, barrel distortion and a small VGA image.
It seems possible to solve these problems. The barrel distortion and the size of the VGA image can be improved by using another lens. We don't have such a lens, but it can be bought for about $150. The intensity probably can be increased by using a higher gain on the camera. However, this is not clear as the camera settings we used for Figure 3 suggest that this is the maximum brightness available. If that is true, the brightness becomes a big problem with this setup.
Of course we could use a custom half-transparent mirror instead of the ones inside the i-glasses. But this is not easy, I expect problems from double reflections caused by the thickness of the half-transparent mirror.

# References


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