1. Introduction

EPFL is part of the Talisman consortium which aims at developing technologies for copyright protection of video data, as described in “Talisman proposal: protection and automated monitoring of digital objects” document. Two main complementary solutions may be used for copyright protection: labeling and watermarking. This proposal is focusing on watermarking technology.

The watermarking is a technique which hides information by a slight modification of the video data. This modification should be:
- Robust to compression and manipulation
- Invisible

The information itself is a number of bits typically ranging from 16 to 128 which can be used to identify the author (signature), the content, the label....etc.
2. Technique Description

2.1 Principle
We present a technique which enables to sign/retrieve information directly on an MPEG-4 compressed bitstream. The information is hidden by a slight modification of the motion vectors.

- **Signing:**
The signing operation is made by extracting the motion vectors directly from the compressed bitstream.
- **Retrieving signature from Bitstream:**
The signature can be retrieved from the bitstream, exactly as if it was a label.
- **Retrieving signature from Video:**
The signature can also be retrieved after the bitstream has been decompressed. In this case, the MPEG-4 video encoder is applied to reconstruct the bitstream from which the motion vectors are extracted.

2.2 Signing technique
The following rule is used for signing a motion vector component, for instance horizontal component \( V \):
Let \( b = \{0, 1\} \), the bit value to embed.

\[
\begin{align*}
\text{if } & ( (V*q+T) \mod 2) \neq b \\
V' &= V + \delta \\
\text{else} & \\
V' &= V \\
\text{and } T &= 2*<\text{SearchWindow used for Motion Estimation}> \\
&\text{and } \delta = (2n+1)/q, \text{ } n \text{ integer.}
\end{align*}
\]

Typically \( n=1 \) for Null motion vector and \( n=0 \) otherwise. \( q \) is used to specify the amplitude of the motion vector modification (\( q=2 \) for half pel signing).

\( V' \) is the signed version of the original motion vector \( V \).

**Block selection:**
The block is selected using a criteria which can be:
1. Vector Modulus,
2. Random choice initiated by a key,
3. DFD energy,
4. The same located block of the next frame is transmitted in Intra mode,
5. ...

2.3 Retrieving technique
Let’s assume we have retrieved a vector \( V' \) from a MPEG-4 bitstream.

The rule is:
\[
b = (V'*q+T) \mod 2
\]
**BISTREAM LEVEL SIGNING SYSTEM**

MPEG-4 Bitstream → Motion Vectors → DCT → Modification → Signed Motion Vectors → MPEG-4 Bitstream

**BISTREAM LEVEL RETRIEVING SYSTEM**

MPEG-4 Bitstream → Motion Vectors → DCT → Reading → SIGNATURE → KEY

**VIDEO LEVEL RETRIEVING SYSTEM**

MPEG-4 Bitstream → MPEG-4 Encoder → BISTREAM LEVEL RETRIEVING SYSTEM

MPEG-4 Encoder

**SIGNATURE**

**SIGNIFIED VIDEO**
3. Implementation & results
The implementation has been made using the Momusys VM Version 7.

Parameter q:
Several sequences have been signed using either q=1 or q=2.
q=1 is very robust to compression (down to 1Mbit/s in CCIR601, 25 frame/s with quantization inter and intra=30)

Signature:
16 bits and 32 bits signature have been used.

Block Selection:
Random selection of 1 block per frame. Two bits are hidden in each motion vector (horizontal and vertical directions). Advanced predicted block have not been used for signing.

Computational complexity:
The computational complexity is negligible. It has not been possible to identify any significant delay of the Momusys software running with or without this signing technique.

Influence on the Bitrate:
The signing process may generate a very slight increase of motion vector entropy which could in turn generate a very little increase of the bitrate.
For instance 4 bits of difference have been measured between a sequence of 5 frames of coastguard compressed with or without signature. This corresponds to a compressed bitstream of 188700 bits (around 0.002 % of bit rate increase).