visage technologies THE CHARACTER ANIMATION COMPANY

MPEG-4 Face and Body Animation (MPEG-4 FBA)

An overview

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1.Introduction

The purpose of this document is to provide background knowledge on MPEG-4 Face and Body Animation (MPEG-4 FBA) [ISO14496] International Standard for the users of Visage Technologies software. It provides the details on the Face Animation Parameters (FAPs) and Body Animation Parameters (BAPs).

Casual users, or developers using only the high-level interfaces of the visage|SDK typically do not need to be familiar with details of MPEG-4 FBA, so they may skip this document. The users wishing to explore the advanced functionalities will find detailed information in this document to support them.

For the face, the MPEG-4 specification defines 66 low-level Face Animation Parameters (FAPs) and two high-level FAPs. The low-level FAPs are based on the study of minimal facial actions and are closely related to muscle actions. They represent a complete set of basic facial actions, and therefore allow the representation of most natural facial expressions. Exaggerated values permit the definition of actions that are normally not possible for humans, but could be desirable for cartoon-like characters. The detailed parameters are given in Annex 1: MPEG-4 Facial Animation Parameters, Annex 2: MPEG-4 Visemes and Annex 3: MPEG-4 FBA primary expressions.

MPEG-4 also defines a standard set of facial feature points (Figure 2 on page 8) that can be used for any application that needs well-defined facial landmarks.

For the body, there are 196 Body Animation Parameters (BAPs). BAP parameters are the angles of rotation of body joints connecting different body parts. These joints include: toe, ankle, knee, hip, spine (C1-C7, T1-T12, L1-L5), shoulder, clavicle, elbow, wrist, and the hand fingers. The detailed parameters are given in Annex 4: MPEG-4 Body Animation Parameters. The rotation angles are assumed to be positive in the counterclockwise rotation direction with respect to the rotation normal.

The hands are capable of performing complicated motions and are included in the body hierarchy. There are totally 29 degrees of freedom on each hand, assuming that the hand has a standard structure with five fingers.

2.Face Animation Parameters (FAPs)

For the face, the MPEG-4 specification defines 66 low-level Face Animation Parameters (FAPs) and two high-level FAPs. The low-level FAPs are based on the study of minimal facial actions and are closely related to muscle actions. They represent a complete set of basic facial actions, and therefore allow the representation of most natural facial expressions. Exaggerated values permit the definition of actions that are normally not possible for humans, but could be desirable for cartoon-like characters.

All low-level FAPs are expressed in terms of the *Face Animation Parameter Units (FAPUs)*, listed in Table 1 and illustrated in Figure 1. These units are defined in order to allow interpretation of the FAPs on any face model in a consistent way, producing reasonable results in terms of expression and speech pronunciation. They correspond to distances between key facial features and are defined in terms of distances between the MPEG-4 facial Feature Points (FPs, see Figure 2). For each FAP it is defined on which FP it acts, in which direction it moves, and which FAPU is used as the unit for its movement. For example, FAP no. 3, `open_jaw`, moves the Feature Point 2.1 (bottom of the chin) downwards and is expressed in MNS (mouth-nose separation) units. The MNS unit is defined as the distance between the nose and the mouth (see Figure 1) divided by 1024. Therefore, in this example, a value of 512 for the FAP no. 3 means that the bottom of the chin moves down by half of the mouth-nose separation. The division by 1024 is introduced in order to have the units sufficiently small that FAPs can be represented in integer numbers. All low-level FAPs are listed and defined in “Annex 1: MPEG-4 Facial Animation Parameters”.

Description		**FAPU Value**
IRISD0 = 3.1.y – 3.3.y = 3.2.y – 3.4.y	Iris diameter (by definition it is equal to the distance between upper ad lower eyelid) in neutral face	IRISD = IRISD0 / 1024
ES0 = 3.5.x – 3.6.x	Eye separation	ES = ES0 / 1024
ENS0 = 3.5.y – 9.15.y	Eye - nose separation	ENS = ENS0 / 1024
MNS0 = 9.15.y – 2.2.y	Mouth - nose separation	MNS = MNS0 / 1024
MW0 = 8.3.x – 8.4.x	Mouth width	MW = MW0 / 1024
AU	Angle Unit	10^{-5} rad

Table 1: Facial Animation Parameter Units (FAPU)

The specification includes two high-level FAPs: `expression` and `viseme`. Expression can contain two out of a predefined list of six basic expressions. Intensity values allow to blend the two expressions. The expressions are are listed and defined in “Annex 3: MPEG-4 FBA primary expressions”.

Similarly, the Viseme parameter can contain two out of a predefined list of 14 visemes, and a blending factor to blend between them. The visemes are are listed and defined in “Annex 2: MPEG-4 Visemes”.

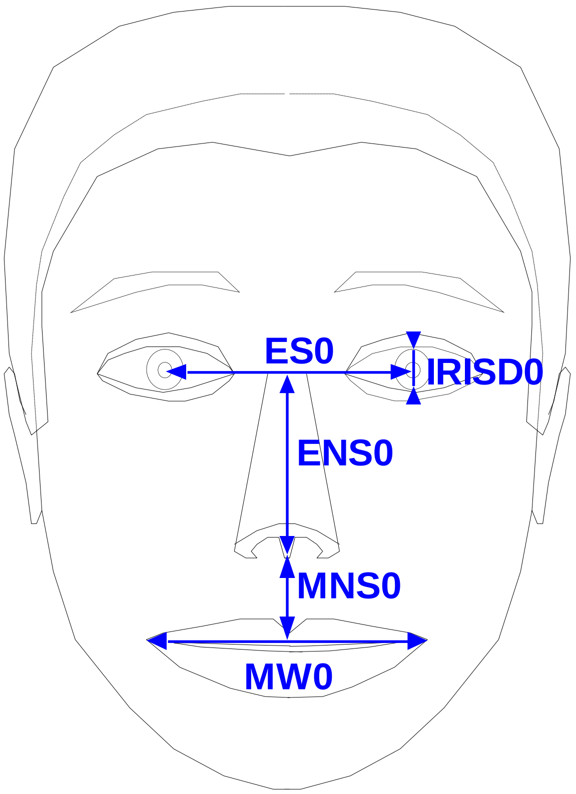

Figure 1: Face Animation Parameter Units (FAPU)

The neutral position of the face (when all FAPs are 0) is defined as follows:

- the coordinate system is right-handed; head axes are parallel to the world axes
- gaze is in direction of Z axis
- all face muscles are relaxed
- eyelids are tangent to the iris
- the pupil is one third of IRISD0
- lips are in contact; the line of the lips is horizontal and at the same height of lip corners
- the mouth is closed and the upper teeth touch the lower ones
- the tongue is flat, horizontal with the tip of tongue touching the boundary between upper and lower teeth (feature point 6.1 touching 9.11, see Figure 2)

All FAPs are expressed as displacements from the positions defined in the neutral face.

Beside the standard itself [ISO14496], there are other excellent references [Pandzic02] covering the subject of MPEG-4 Face Animation and we recommend more serious users to obtain these.

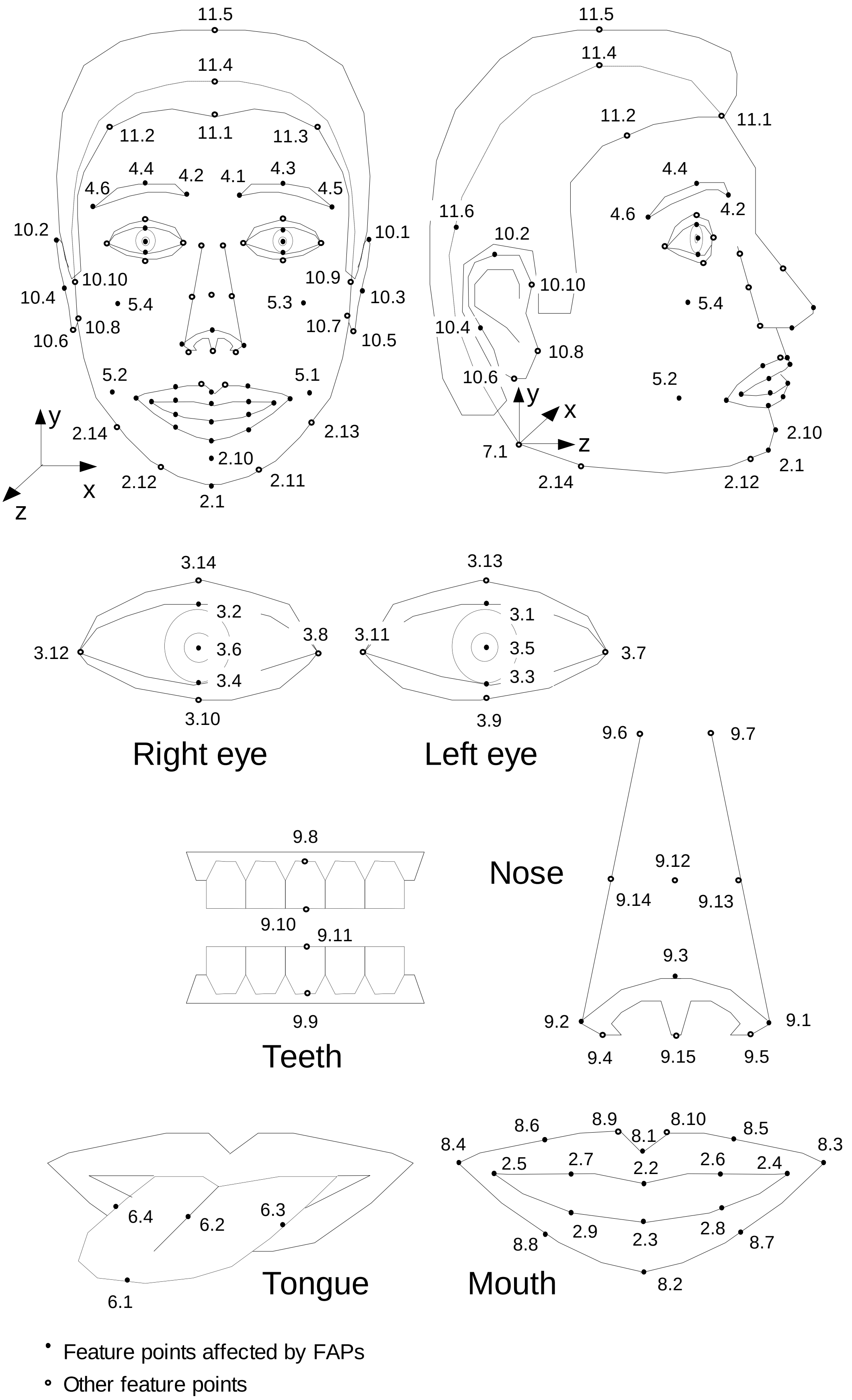

Figure 2: Facial Feature Points (FP)

2.1 FAP grouping and masking

This section is interesting only for users who wish to understand more about the coding of FAPs in the FBA files/bitstreams.

FAPs are grouped into 10 groups as shown in this table:

Group	**Number of FAPs in the group**
1: visemes and expressions	2
2: jaw, chin, inner lowerlip, cornerlips, midlip	16
3: eyeballs, pupils, eyelids	12
4: eyebrow	8
5: cheeks	4
6: tongue	5
7: head rotation	3
8: outer lip positions	10
9: nose	4
10: ears	4

The table of FAPs in "Annex 1: MPEG-4 Facial Animation Parameters" indicates for each FAP to which group it belongs.

When FAPs are encoded into an FBA file/bitstream, a masking mechanism is used to select which FAPs are encoded and which are not, and how the decoder shall behave when decoding the bitstream. The purpose of this mechanism is to achieve more efficient coding, i.e. the FAPs that are not used do not need to be encoded. FAPs are selected by using a two level mask hierarchy. The first level is the *mask type*. There is one mask type parameter for each group. The mask type can be 0, 1, 2 or 3. The meaning of the values is as follows:

0. no FAPs are encoded in the group.
1. a *group mask* is set indicating which FAPs in the group are encoded. FAPs not selected by the *group mask* retain their previous value.
2. a *group mask* is set indicating which FAPs in the group are encoded. FAPs not selected by the *group mask* retain must be interpolated by the decoder.
3. all FAPs in the group are encoded.

If mask type for a particular group is 1 or 2, a *group mask* must be defined for this group. The group mask has one value for each FAP in the group. So, for example, the length of the group mask for group 1 is 2; for group 2 it is 16. Each value corresponds to one FAP and can be 0 or 1. 1 means that the FAP is encoded and used. If the value is 0, the FAP is not encoded in the bitstream, but depending on the value of the mask type the decoder can either interpolate this FAP from other FAPs (e.g. using left-right symmetry), or retain a previously set value for that FAP.

If FAPs are encoded from an ASCII FAP file, the FAP masks are set in the Encoder Parameter File (EPF). The format of the EPF file is described in Annex C: The EPF file format.

When visage|SDK is used to encode FAPs, the mask types and group masks are set in the FAPs class.

3.Body Animation Parameters (BAPs)

For the body, there are 186 Body Animation Parameters (BAPs), plus 110 extension (user-defined) parameters, which makes the total of 296 BAPs. BAP parameters are the angles of rotation of body joints connecting different body parts. These joints include: toe, ankle, knee, hip, spine (C1-C7, T1-T12, L1-L5), shoulder, clavicle, elbow, wrist, and the hand fingers. The detailed parameters are given in Annex 4: MPEG-4 Body Animation Parameters. The rotation angles are assumed to be positive in the counterclockwise rotation direction with respect to the rotation normal.

The unit of rotations (BAPU) is defined as 10^{-5} radians. The unit of translation BAPs (BAPs HumanoidRoot_tr_vertical, HumanoidRoot_tr_lateral, HumanoidRoot_tr_frontal) is defined in millimeters.

The neutral body position (when all BAPs are 0) is defined by standing posture, illustrated in Figure 3. This posture is defined as follows: the feet should point to the front direction, the two arms should be placed on the side of the body with the palm of the hands facing inward.

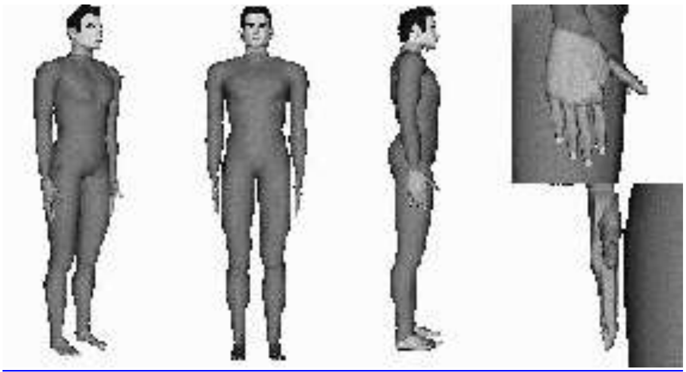

Figure 3: Default body posture

3.1 Detailed body topology and degrees of freedom

The ***degrees of freedom (DOF)*** sufficient to locate and animate a human body are decomposed into six DOF for the global location and 180 DOF for the internal mobilities. The topology of the suggested joints is given below. The hands are optional with an additional set of joints.

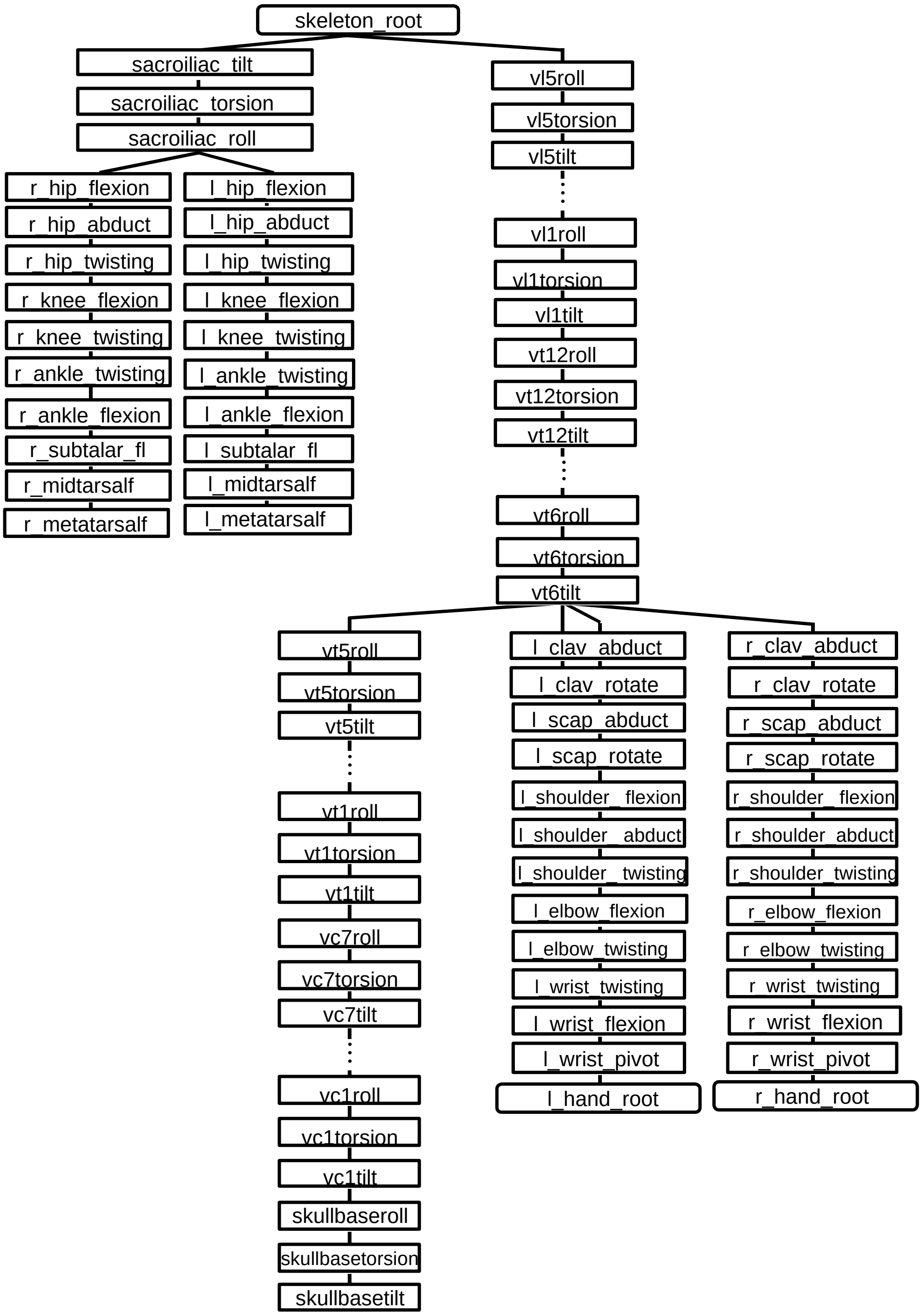

Figure 4: Body topology

Lower Body

From the skeleton_root node, three DOF allow flexible pelvic orientation followed by nine DOF per leg, from the hip joint to the toe joint.

First, the pelvic mobilities are very important to convey a gender personification to the motion. The naming convention of these mobilities is also used for the spine DOF. The degrees of freedom are:

sacroiliac_tilt : forward-backward motion in the sagital plane

sacroiliac _torsion :rotation along the body vertical axis (defined by skeleton root)

sacroiliac _roll : side to side swinging in the coronal plane

The leg mobilities follow in this order :

At the hip :

hip_flexion : forward-backward rotation in the sagital plane

hip_abduct : sideward opening in the coronal plane

hip_twisting : rotation along the thigh axis.

At the knee :

knee_flexion : flexion-extension of the leg in the sagital plane

knee_twisting : rotation along the shank axis.

At the ankle :

ankle_twisting : rotation along the shank axis. This joint is redundant with the knee_twisting except that only the foot rotate and not the shank segment.

ankle_flexion : flexion-extension of the foot in the sagital plane

At the foot complex:

The foot complex region is completely described with three degrees of freedom with independent position and orientation : the subtalar joint, the *mid_foot* joint, between the subtalar joint and the toe joint to capture complex internal relative movement of the foot bones (also called the navicular joint in the literature).

subtalar_flexion : sideward orientation of the foot

midtarsal_flexion : internal twisting of the foot (also called navicular joint in anatomy)

metatorsal_flexion : up and down rotation of the toe in the sagital plane

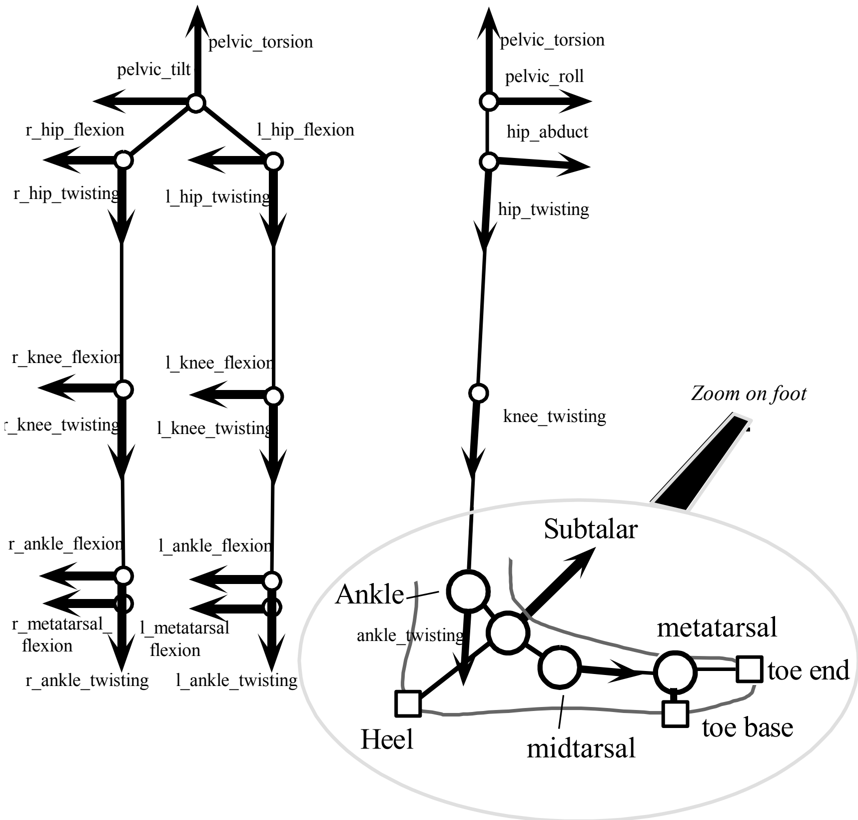

Figure 5: Front and side views of the mobilities of the leg

Upper Body

The suggested upper body degrees of freedom and their corresponding axes of rotation are shown in the following diagrams.

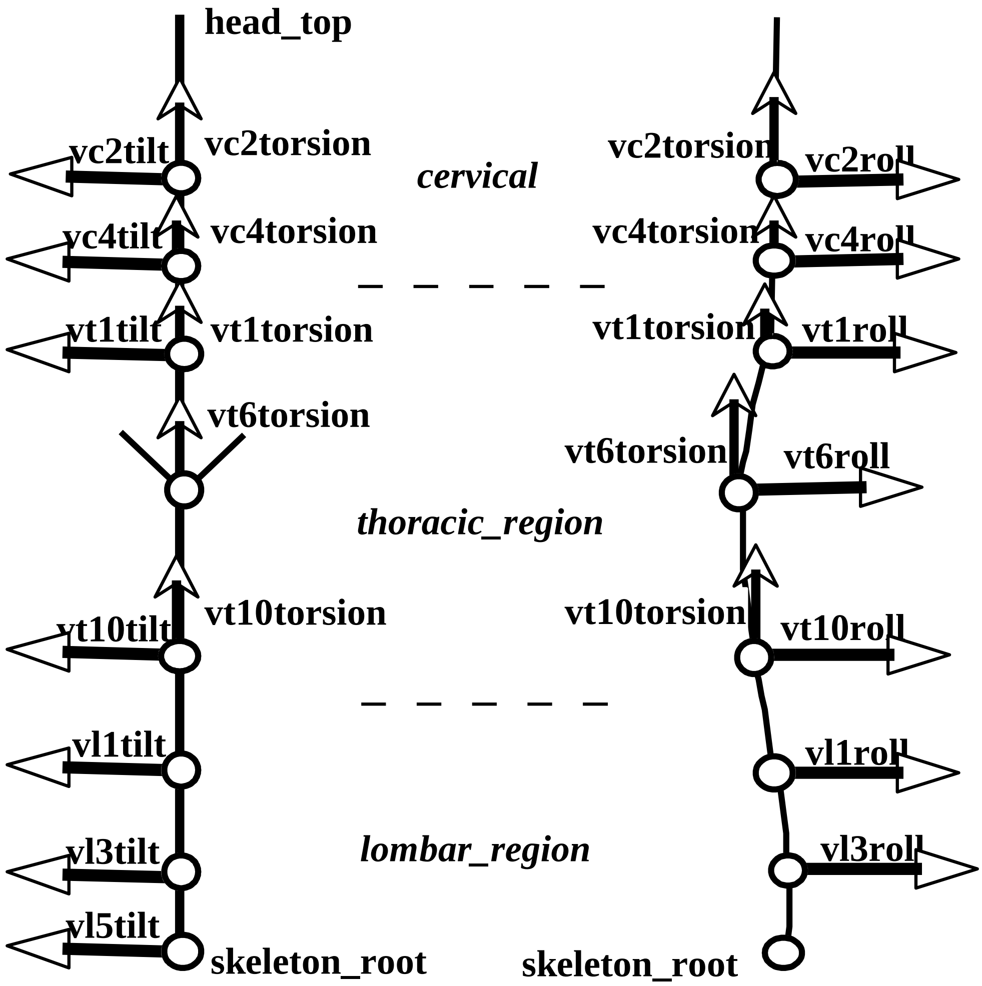

Figure 6: Front and side views of the mobilities of the simple spine

At the spine:

The vertebrae are dispatched into 5 *lumbar*, 12 *thoracic* and *cervical* groups.A total of 72 DOFs are defined for the spine, therefore complex applications with whole spine mobilities can be developed. However, typically, the application will use simpler spines that balance the computational speed, with the realism of animation. Therefore, 5 groups of spine are defined, from the simplest to most complex. It is suggested that the spine groups (Spine1, Spine2) are used for simple spine.

At the arms:

The arm structure is attached to the spine. The mobilities are similar to the ones defined for the leg when the arm is twisted such that the hand palm is facing backward. The name of the DOF respects this structure similarity.

Strictly speaking, the two clavicula DOF and the two scapula DOF are not part of the arm structure, they only initiate its articulated chain. The scapula joints improve the mechanical model of the shoulder complex. It should be noted that such a chain representation is only a step toward a mechanically correct representation of this region, mainly because the shoulder complex is in fact a closed loop mechanism. The scapula holds the same mobility as the clavicula but very close to the shoulder joint.

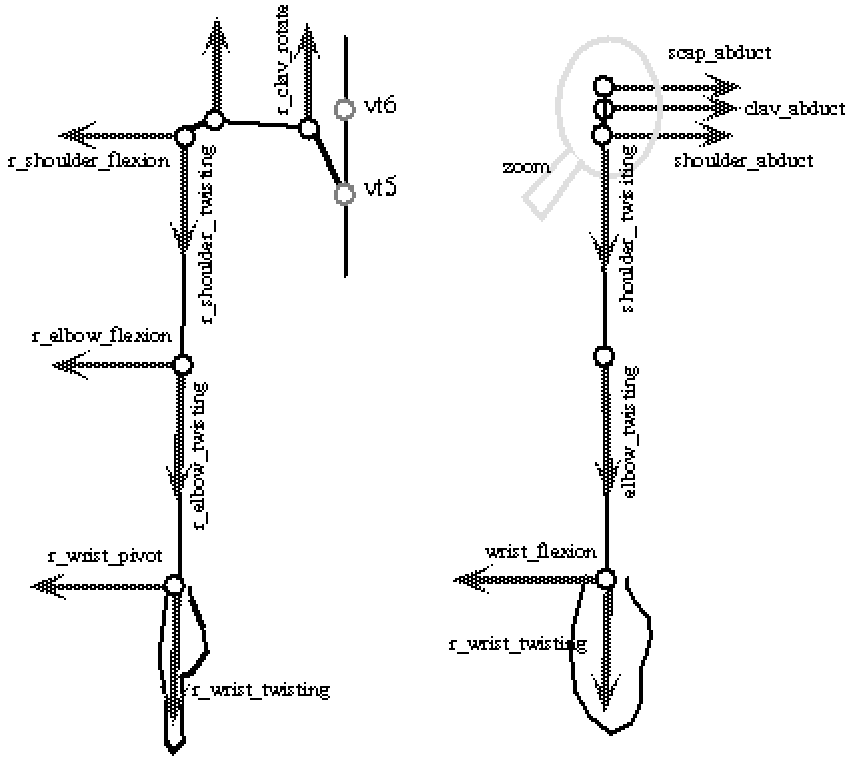

Figure 7: Front and side views of the mobilities of the arm in rest position

At the clavicula :

sternoclavicular_abduct : up and down motion in the coronal plane

sternoclavicular _rotate : rotation in the transverse plane

At the scapula :

acromioclavicular_abduct : up and down motion in the coronal plane

acromioclavicular _rotate : rotation in the transverse plane

At the shoulder :

shoulder_flexion : forward-backward motion in the sagital plane

shoulder_abduct : sideward motion in the coronal plane

shoulder_twisting : along the forearm axis

At the elbow :

elbow_flexion : flexion-extension of the arm in the sagital plane

elbow_twisting : along the arm axis.

At the wrist :

wrist_twisting : along the arm axis. This DOF is redundant with the elbow twisting except that only the hand rotate and not the forearm

wrist_flexion : rotation of the hand in the coronal plane

wrist_pivot : rotation of the hand in the sagital planes

Head rotations

Note that there are three BAPs defined for head rotation : skullbase_roll, skullbase_torsion, skullbase_tilt . There are also 3 FAPs for head rotation. If both FAPs and BAPs are used for head rotation, then these FAPs shall denote the head rotation with respect to the skullbase coordinate system.

Hands

The hand mobilities have a standard structure for the five fingers. This structure is organized as :

a **flexing** DOF for closing the first knuckle a **pivoting** rotation for the lateral mobility of the finger

a **twisting** rotation for small adjustments of the finger grasping orientation

two other **flexing** DOF for closing the second and third knuckles

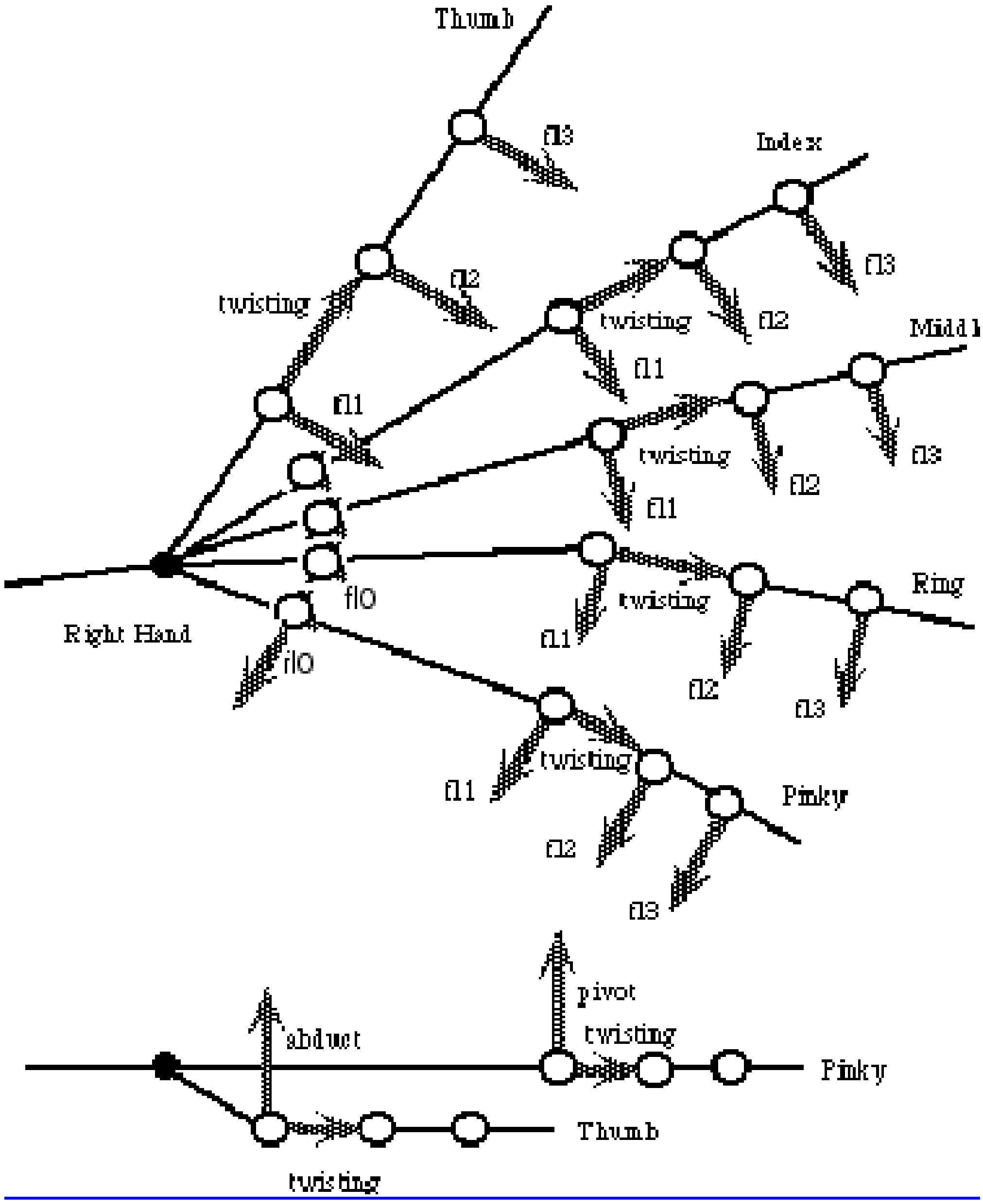

Figure 8: Mobilities of the right hand

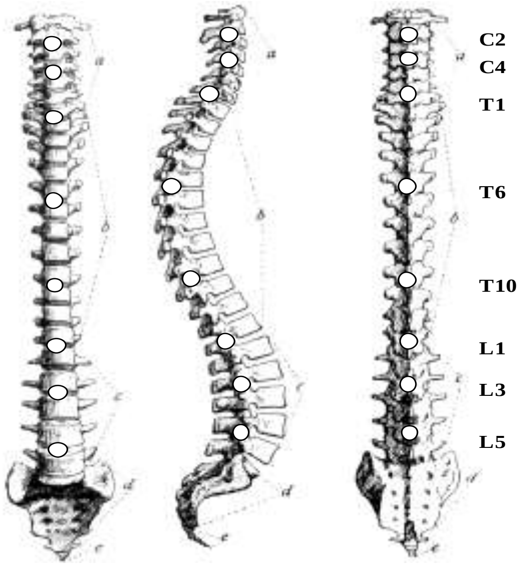

Figure 9: Example spine mobilities

3.2 BAP grouping and masking

This section is interesting only for users who wish to understand more about the coding of BAPs in the FBA files/bitstreams.

BAPs are grouped into 24 groups as shown in this table:

GROUP ID	GROUP NAME	BAPS
1	Pelvis	sacroiliac_tilt, sacroiliac_torsion, sacroiliac_roll (1,2,3)
2	Left leg1	l_hip_flexion, l_hip_abduct, l_knee_flexion, l_ankle_flexion (4,6,10,14)
3	Right leg1	r_hip_flexion, r_hip_abduct, r_knee_flexion, r_ankle_flexion (5,7,11,15)
4	Left leg2	l_hip_twisting, l_knee_twisting, l_ankle_twisting, l_subtalar_flexion, l_midtarsal_flexion, l_metatarsal_flexion (8,12,16,18,20,22)
5	Right leg2	r_hip_twisting, r_knee_twisting, r_ankle_twisting, r_subtalar_flexion, r_midtarsal_flexion, r_metatarsal_flexion (9,13,17,19,21,23)
6	Left arm1	l_shoulder_flexion, l_shoulder_abduct, l_shoulder_twisting, l_elbow_flexion, l_wrist_flexion (32,34,36,38,42)
7	Right arm1	r_shoulder_flexion, r_shoulder_abduct, r_shoulder_twisting, r_elbow_flexion, r_wrist_flexion (33,35,37,39,43)
8	Left arm2	l_sternoclavicular_abduct, l_sternoclavicular_rotate, l_acromioclavicular_abduct, l_acromioclavicular_rotate, l_elbow_twisting, l_wrist_pivot, l_wrist_twisting (24,26,28,30,40,44,46)
9	Right arm2	r_sternoclavicular_abduct, r_sternoclavicular_rotate, r_acromioclavicular_abduct, r_acromioclavicular_rotate, r_elbow_twisting, r_wrist_pivot, r_wrist_twisting (25,27,29,31,41,45,47)
10	Spine1	skullbase_roll, skullbase_torsion, skullbase_tilt, vc4roll, vc4torsion, vc4tilt, vt6roll, vt6torsion, vt6tilt, vl3roll, vl3torsion, vl3tilt, (48,49,50,60,61,62,87,88,89,114,115,116)

11	Spine2	vc2roll, vc2torsion, vc2tilt, vt1roll, vt1torsion, vt1tilt, vt10roll, vt10torsion, vt10tilt, vl1roll, vl1torsion, vl1tilt, vl5roll, vl5torsion, vl5tilt (54,55,56,72,73,74,99,100,101,108, 109,110,120,121,122)
12	Spine3	vc3roll, vc3torsion, vc3tilt, vc6roll, vc6torsion, vc6tilt, vt4roll, vt4torsion, vt4tilt, vt8roll, vt8torsion, vt8tilt, vt12roll, vt12torsion, vt12tilt vl4roll, vl4torsion, vl4tilt, (57,58,59,66,67,68,81,82,83,93,94,95, 105,106,107,117,118,119)
13	Spine4	vc5roll, vc5torsion, vc5tilt, vc7roll, vc7torsion, vc7tilt vt2roll, vt2torsion, vt2tilt, vt7roll, vt7torsion, vt7tilt, vt11roll, vt11torsion, vt11tilt, vl2roll, vl2torsion, vl2tilt, (63,64,65,69,70,71,75,76,77,90,91, 92,102,103,104,111,112,113)
14	Spine5	vc1roll, vc1torsion, vc1tilt, vt3roll, vt3torsion, vt3tilt, vt5roll, vt5torsion, vt5tilt, vt9roll, vt9torsion, vt9tilt, (51,52,53,78,79,80,84,85,86,96,97,98)
15	Left hand1	l_pinky1_flexion, l_pinky2_flexion, l_pinky3_flexion, l_ring1_flexion, l_ring2_flexion, l_ring3_flexion, l_middle1_flexion, l_middle2_flexion,l_middle3_flexion, l_index1_flexion, l_index2_flexion, l_index3_flexion, l_thumb1_flexion, l_thumb1_pivot, l_thumb2_flexion, l_thumb3_flexion (125,131,133,137,143,145,149,155,157, 161,167,169,171,173,177,179)

16	Right hand1	r_pinky1_flexion, r_pinky2_flexion, r_pinky3_flexion, r_ring1_flexion, r_ring2_flexion, r_ring3_flexion, r_middle1_flexion, r_middle2_flexion,r_middle3_flexion, r_index1_flexion, r_index2_flexion, r_index3_flexion, r_thumb1_flexion, r_thumb1_pivot, r_thumb2_flexion, r_thumb3_flexion (126,132,134,138,144,146,150,156,158, 162,168,170,172,174,178,180)
17	Left hand2	l_pinky0_flexion, l_pinky1_ pivot, l_pinky1_twisting, l_ring0_flexion, l_ring1_ pivot, l_ring1_twisting, l_middle0_flexion, l_middle1_ pivot, l_middle1_twisting, l_index0_flexion, l_index1_ pivot, l_index1_twisting, l_thumb1_twisting (123,127,129,135,139,141,147, 151,153,159,163,165,175)
18	Right hand2	r_pinky0_flexion, r_pinky1_ pivot, r_pinky1_twisting, r_ring0_flexion, r_ring1_ pivot, r_ring1_twisting, r_middle0_flexion, r_middle1_ pivot, r_middle1_twisting, r_index0_flexion, r_index1_ pivot, r_index1_twisting, r_thumb1_twisting (124,128,130,136,140,142,148, 152,154,160,164,166,176)
19	Global positioning	HumanoidRoot_tr_vertical, HumanoidRoot_tr_lateral, HumanoidRoot_tr_frontal, HumanoidRoot_rt_body_turn, HumanoidRoot_rt_body_roll, HumanoidRoot_rt_body_tilt (181,182,183,184,185,186)

Additionally, groups 20 to 24 contain extension BAPs. Extension BAPs are user-defined BAPs. Thus, the extension BAP groups are as follows:

GROUP ID	**GROUP NAME**	**BAPs**
20	Extension1	187…208
21	Extension2	209…230
22	Extension3	231…252
23	Extension4	253…274
24	Extension5	275…296

When BAPs are encoded into an FBA file/bitstream, a masking mechanism is used to select which BAPs are encoded and which are not. The purpose of this mechanism is to achieve more efficient coding, i.e. the BAPs that are not used do not need to be encoded. BAPs are selected by using a two level mask hierarchy. The first level is the *mask type*. There is one mask type parameter for each group. The mask type can be 0, 1 or 3. The meaning of the values is as follows:

0: no BAPs are encoded in the group.

1: a *group mask* is set indicating which BAPs in the group are encoded.

3: all BAPs in the group are encoded.

If mask type for a particular group is 1, a *group mask* must be defined for this group. The group mask has one value for each BAP in the group. So, for example, the length of the group mask for group 1 is 3; for group 2 it is 4 etc. Each value corresponds to one BAP and can be 0 or 1. 1 means that the BAP is encoded. If the value is 0, the BAP is not encoded in the bitstream.

If BAPs are encoded from an ASCII BAP file, the BAP masks are set in the Encoder Parameter File (EPF). The format of the EPF file is described in Annex C: The EPF file format.

When visage|SDK is used to encode BAPs, the mask types and group masks are set in the BAPs class.

4.Coding parameters

When FAPs and BAPs are encoded into the bitstream/file, several additional parameters are used to control the encoding and later decoding process. visage|SDK and visage|interactive use default values which are appropriate for most purposes. Most of the time users will not need to change or even understand these parameters. If necessary, they can be set through appropriate methods in visage|SDK or, in case of encoding from an ASCII FAP file, the parameters are set in the EPF file.

The main purpose of tweaking these parameters is to achieve better coding efficiency, i.e. smaller files or lower bitrates. Considerable improvements over default parameters can be achieved, particularly in special cases.

The coding parameters are the following:

frame_rate – This is an 8 bit unsigned integer indicating the reference frame rate of the sequence. Range: 0-255

seconds – This is a 4 bit unsigned integer indicating the fractional reference frame rate. The frame rate is computed as follows frame rate = (frame_rate + seconds/16). Range: 0-15

frequency_offset -- This is a 1-bit flag which when set to '1' indicates that the frame rate uses the NTSC frequency offset of 1000/1001. This bit would typically be set when frame_rate = 24, 30 or 60, in which case the resulting frame rate would be 23.97, 29.94 or 59.97 respectively. When set to '0' no frequency offset is present. I.e. if (frequency_offset ==1) frame rate = (1000/1001) * (frame_rate + seconds/16). Range: 0-1

fap_quant – This is a 5-bit unsigned integer which is the quantization scale factor used to compute the FAPi table step size. Range: 0-31

bap_quant – This is a 5-bit unsigned integer which is the quantization scale factor used to compute the BAPi table step size. Range: 0-31

i_max – This is an array of 73 integer values setting the maximum value that each FAP can take when an I frame is encoded. If these values are not big enough, i.e. if a FAP goes out of range while encoding, results are unpredictable. The first 7 values correspond to viseme1, viseme2, viseme blend, expression1 , expression1 intensity, expression2 , expression2 intensity. The rest of the parameters correspond to the low level FAPs.

i_min – This is an array of 73 integer values setting the minimum value that each FAP can take when an I frame is encoded. If these values are not low enough, i.e. if a FAP goes out of range while encoding, results are unpredictable. The first 7 values correspond to viseme1, viseme2, viseme blend, expression1 , expression1 intensity, expression2 , expression2 intensity. The rest of the parameters correspond to the low level FAPs.

p_max – This is an array of 73 integer values setting the maximum value that each FAP can take when an P frame is encoded. If these values are not big enough, i.e. if a FAP goes out of range while encoding, results are unpredictable. The first 7 values correspond to viseme1, viseme2, viseme blend, expression1 , expression1 intensity, expression2 , expression2 intensity. The rest of the parameters correspond to the low level FAPs.

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bap_i_max – This is an array of 296 integer values setting the maximum value that each BAP can take when an I frame is encoded. If these values are not big enough, i.e. if a FAP goes out of range while encoding, results are

bap_i_min – This is an array of 296 integer values setting the minimum value that each BAP can take when an I frame is encoded. If these values are not low enough, i.e. if a BAP goes out of range while encoding, results are unpredictable.

bap_p_max – This is an array of 296 integer values setting the maximum value that each BAP can take when an P frame is encoded. If these values are not big enough, i.e. if a BAP goes out of range while encoding, results are unpredictable.

bap_p_min – This is an array of 296 integer values setting the minimum value that each BAP can take when an P frame is encoded. If these values are not low enough, i.e. if a BAP goes out of range while encoding, results are unpredictable.

5.References

[ISO14496] ISO/IEC 14496 - MPEG-4 International Standard, Moving Picture Experts Group, www.cselt.it/mpeg

[Pandzic02] MPEG-4 Facial Animation - The standard, implementations, applications, Igor S. Pandzic, R. Forchheimer, Editors, John Wiley & Sons Ltd.

6. Annex 1: MPEG-4 Facial Animation Parameters

MPEG-4 FAP definitions, group assignments, and step sizes. FAP names may contain letters with the following meaning: l = left, r = right, t = top, b = bottom, i = inner, o = outer, m = middle. The quantizer step-size is a scaling factor for coding.

#	FAP name	FAP description	units	Uni-orBidir	Pos motion	Grp	FDP subgrp num	Quant step size QP	Min/Max I-Frame quantized values	Min/Max P-Frame quantized values
1	viseme	Set of values determining the mixture of two visemes for this frame (e.g. pbm, fv, th)	na	na	na	1	na	1	viseme_blend: +63	viseme_blend: +-63
2	expression	A set of values determining the mixture of two facial expression	na	na	na	1	na	1	expression_intensity1, expression_intensity2: +63	expression_intensity1, expression_intensity2: +-63
3	open_jaw	Vertical jaw displacement (does not affect mouth opening)	MNS	U	down	2	1	4	+1080	+360
4	lower_t_midlip	Vertical top middle inner lip displacement	MNS	B	down	2	2	2	+-600	+-180
5	raise_b_midlip	Vertical bottom middle inner lip displacement	MNS	B	up	2	3	2	+-1860	+-600
6	stretch_l_cornerlip	Horizontal displacement of left inner lip corner	MW	B	left	2	4	2	+-600	+-180
7	stretch_r_cornerlip	Horizontal displacement of right inner lip corner	MW	B	right	2	5	2	+-600	+-180
8	lower_t_lip_lm	Vertical displacement of midpoint between left corner and middle of top inner lip	MNS	B	down	2	6	2	+-600	+-180

9	lower_t_lip_rm	Vertical displacement of midpoint between right corner and middle of top inner lip	MNS	B	down	2	7	2	+-600	+-180
10	raise_b_lip_lm	Vertical displacement of midpoint between left corner and middle of bottom inner lip	MNS	B	up	2	8	2	+-1860	+-600
11	raise_b_lip_rm	Vertical displacement of midpoint between right corner and middle of bottom inner lip	MNS	B	up	2	9	2	+-1860	+-600
12	raise_l_cornerlip	Vertical displacement of left inner lip corner	MNS	B	up	2	4	2	+-600	+-180
13	raise_r_cornerlip	Vertical displacement of right inner lip corner	MNS	B	up	2	5	2	+-600	+-180
14	thrust_jaw	Depth displacement of jaw	MNS	U	forwar d	2	1	1	+600	+180
15	shift_jaw	Side to side displacement of jaw	MW	B	right	2	1	1	+-1080	+-360
16	push_b_lip	Depth displacement of bottom middle lip	MNS	B	forwar d	2	3	1	+-1080	+-360
17	push_t_lip	Depth displacement of top middle lip	MNS	B	forwar d	2	2	1	+-1080	+-360
18	depress_chin	Upward and compressing movement of the chin (like in sadness)	MNS	B	up	2	10	1	+-420	+-180
19	close_t_l_eyelid	Vertical displacement of top left eyelid	IRIS D	B	down	3	1	1	+-1080	+-600
20	close_t_r_eyelid	Vertical	IRIS	B	down	3	2	1	+-1080	+-600

		displacement of top right eyelid	D							
21	close_b_l_eyelid	Vertical displacement of bottom left eyelid	IRIS D	B	up	3	3	1	+-600	+-240
22	close_b_r_eyelid	Vertical displacement of bottom right eyelid	IRIS D	B	up	3	4	1	+-600	+-240
23	yaw_l_eyeball	Horizontal orientation of left eyeball	AU	B	left	3	na	128	+-1200	+-420
24	yaw_r_eyeball	Horizontal orientation of right eyeball	AU	B	left	3	na	128	+-1200	+-420
25	pitch_l_eyeball	Vertical orientation of left eyeball	AU	B	down	3	na	128	+-900	+-300
26	pitch_r_eyeball	Vertical orientation of right eyeball	AU	B	down	3	na	128	+-900	+-300
27	thrust_l_eyeball	Depth displacement of left eyeball	ES	B	forwar d	3	na	1	+-600	+-180
28	thrust_r_eyeball	Depth displacement of right eyeball	ES	B	forwar d	3	na	1	+-600	+-180
29	dilate_l_pupil	Dilation of left pupil	IRIS D	B	growin g	3	5	1	+-420	+-120
30	dilate_r_pupil	Dilation of right pupil	IRIS D	B	growin g	3	6	1	+-420	+-120
31	raise_l_i_eyebrow	Vertical displacement of left inner eyebrow	ENS	B	up	4	1	2	+-900	+-360
32	raise_r_i_eyebrow	Vertical displacement of right inner eyebrow	ENS	B	up	4	2	2	+-900	+-360
33	raise_l_m_eyebrow	Vertical displacement of left middle eyebrow	ENS	B	up	4	3	2	+-900	+-360
34	raise_r_m_eyebro w	Vertical displacement of right middle eyebrow	ENS	B	up	4	4	2	+-900	+-360

35	raise_l_o_eyebrow	Vertical displacement of left outer eyebrow	ENS	B	up	4	5	2	+-900	+-360
36	raise_r_o_eyebrow	Vertical displacement of right outer eyebrow	ENS	B	up	4	6	2	+-900	+-360
37	squeeze_l_eyebrow	Horizontal displacement of left eyebrow	ES	B	right	4	1	1	+-900	+-300
38	squeeze_r_eyebro w	Horizontal displacement of right eyebrow	ES	B	left	4	2	1	+-900	+-300
39	puff_l_cheek	Horizontal displacement of left cheeck	ES	B	left	5	1	2	+-900	+-300
40	puff_r_cheek	Horizontal displacement of right cheeck	ES	B	right	5	2	2	+-900	+-300
41	lift_l_cheek	Vertical displacement of left cheek	ENS	U	up	5	3	2	+-600	+-180
42	lift_r_cheek	Vertical displacement of right cheek	ENS	U	up	5	4	2	+-600	+-180
43	shift_tongue_tip	Horizontal displacement of tongue tip	MW	B	right	6	1	1	+-1080	+-420
44	raise_tongue_tip	Vertical displacement of tongue tip	MNS	B	up	6	1	1	+-1080	+-420
45	thrust_tongue_tip	Depth displacement of tongue tip	MW	B	forwar d	6	1	1	+-1080	+-420
46	raise_tongue	Vertical displacement of tongue	MNS	B	up	6	2	1	+-1080	+-420
47	tongue_roll	Rolling of the tongue into U shape	AU	U	concav e upward	6	3, 4	512	+300	+60
48	head_pitch	Head pitch angle from top of spine	AU	B	down	7	na	170	+-1860	+-600
49	head_yaw	Head yaw angle from top of spine	AU	B	left	7	na	170	+-1860	+-600
50	head_roll	Head roll angle from top of spine	AU	B	right	7	na	170	+-1860	+-600

51	lower_t_midlip _o	Vertical top middle outer lip displacement	MNS	B	down	8	1	2	+-600	+-180
52	raise_b_midlip_o	Vertical bottom middle outer lip displacement	MNS	B	up	8	2	2	+-1860	+-600
53	stretch_l_cornerlip _o	Horizontal displacement of left outer lip corner	MW	B	left	8	3	2	+-600	+-180
54	stretch_r_cornerlip _o	Horizontal displacement of right outer lip corner	MW	B	right	8	4	2	+-600	+-180
55	lower_t_lip_lm _o	Vertical displacement of midpoint between left corner and middle of top outer lip	MNS	B	down	8	5	2	+-600	+-180
56	lower_t_lip_rm _o	Vertical displacement of midpoint between right corner and middle of top outer lip	MNS	B	down	8	6	2	+-600	+-180
57	raise_b_lip_lm_o	Vertical displacement of midpoint between left corner and middle of bottom outer lip	MNS	B	up	8	7	2	+-1860	+-600
58	raise_b_lip_rm_o	Vertical displacement of midpoint between right corner and middle of bottom outer lip	MNS	B	up	8	8	2	+-1860	+-600
59	raise_l_cornerlip_o	Vertical displacement of left outer lip corner	MNS	B	up	8	3	2	+-600	+-180
60	raise_r_cornerlip _o	Vertical displacement of right outer lip corner	MNS	B	up	8	4	2	+-600	+-180
61	stretch_l_nose	Horizontal	ENS	B	left	9	1	1	+-540	+-120

		displacement of left side of nose								
62	stretch_r_nose	Horizontal displacement of right side of nose	ENS	B	right	9	2	1	+-540	+-120
63	raise_nose	Vertical displacement of nose tip	ENS	B	up	9	3	1	+-680	+-180
64	bend_nose	Horizontal displacement of nose tip	ENS	B	right	9	3	1	+-900	+-180
65	raise_l_ear	Vertical displacement of left ear	ENS	B	up	10	1	1	+-900	+-240
66	raise_r_ear	Vertical displacement of right ear	ENS	B	up	10	2	1	+-900	+-240
67	pull_l_ear	Horizontal displacement of left ear	ENS	B	left	10	3	1	+-900	+-300
68	pull_r_ear	Horizontal displacement of right ear	ENS	B	right	10	4	1	+-900	+-300

7. Annex 2: MPEG-4 Visemes

Viseme no.	**Viseme name**	**Some corresponding phonemes**	**Example**	**Visual example**
0	sil	none	N/A	
1	PP	p, b, m	Put, bed, mill	
2	FF	f, v	Far, voice	
3	TH	T, D	Think, that	
4	DD	t, d	Tip, doll	

5	kk	k, g	Call, gas	
6	CH	tS, dZ, S	Chair, join, she	
7	SS	s, z	Sir, zeal	
8	nn	n, l	Lot, not	
9	RR	r	Red	

10	aa	A:	Car	
11	E	e	Bed	
12	ih	I	Tip	
13	oh	Q	Top	
14	ou	U	book	

8. Annex 3: MPEG-4 FBA primary expressions

#	Expression name	textual description
1	Joy	The eyebrows are relaxed. The mouth is open and the mouth corners pulled back toward the ears.
2	Sadness	The inner eyebrows are bent upward. The eyes are slightly closed. The mouth is relaxed.
3	Anger	The inner eyebrows are pulled downward and together. The eyes are wide open. The lips are pressed against each other or opened to expose the teeth.
4	Fear	The eyebrows are raised and pulled together. The inner eyebrows are bent upward. The eyes are tense and alert.
5	Disgust	The eyebrows and eyelids are relaxed. The upper lip is raised and curled, often asymmetrically.
6	surprise	The eyebrows are raised. The upper eyelids are wide open, the lower relaxed. The jaw is opened.

9.Annex 4: MPEG-4 Body Animation Parameters

BAP ID	BAP NAME	DESCRIPTION	Quant step size	Min/Max I-Frame quantized values	Min/Max P-Frame quantized values
1	sacroiliac_tilt	Forward-backward motion of the pelvis in the sagittal plane	64	-960/ +960	-600/ +600
2	sacroiliac_torsion	Rotation of the pelvis along the body vertical axis (defined by skeleton root)	64	-960/ +960	-600/ +600
3	sacroiliac_roll	Side to side swinging of the pelvis in the coronal plane	64	-960/ +960	-600/ +600
4	l_hip_flexion	Forward-backward rotation in the sagittal plane	128	-1260/ +1260	-600/ +600
5	r_hip_flexion	Forward-backward rotation in the sagittal plane	128	-1260/ +1260	-600/ +600
6	l_hip_abduct	Sideward opening in the coronal plane	128	-960/ +480	-600/ +600
7	r_hip_abduct	Sideward opening in the coronal plane	128	-960/ +480	-600/ +600
8	l_hip_twisting	Rotation along the thigh axis	256	-960/ +960	-360/ +360
9	r_hip_twisting	Rotation along the thigh axis	256	-960/ +960	-360/ +360
10	l_knee_flexion	Flexion-extension of the leg in the sagittal plane	128	-1500/ +180	-600/ +600
11	r_knee_flexion	Flexion-extension of the leg in the sagittal plane	128	-1500/ +180	-600/ +600
12	l_knee_twisting	Rotation along the shank axis.	256	-960/ +960	-360/ +360
13	r_knee_twisting	Rotation along the shank axis.	256	-960/ +960	-360/ +360
14	l_ankle_flexion	Flexion-extension of the foot in the sagittal plane	128	-780/ +780	-600/ +600
15	r_ankle_flexion	Flexion-extension of the foot in the sagittal plane	128	-780/ +780	-600/ +600
16	l_ankle_twisting	Rotation along the knee axis	256	-960/ +960	-360/ +360
17	r_ankle_twisting	Rotation along the knee axis	256	-960/ +960	-360/ +360

18	l_subtalar_flexion	Sideward orientation of the foot	256	-780/ +780	-600/ +600
19	r_subtalar_flexion	Sideward orientation of the foot	256	-780/ +780	-600/ +600
20	l_midtarsal_twisting	Internal twisting of the foot (also called navicular joint in anatomy)	256	-180/ +180	-120/ +120
21	r_midtarsal_ twisting	Internal twisting of the foot (also called navicular joint in anatomy)	256	-180/ +180	-120/ +120
22	l_metatarsal_flexion	Up and down rotation of the toe in the sagittal plane	256	-780/ +780	-600/ +600
23	r_metatarsal_flexion	Up and down rotation of the toe in the sagittal plane	256	-780/ +780	-600/ +600
24	l_sternoclavicular_abduct	Up and down motion in the coronal plane	128	-60/ +240	-120/ +120
25	r_sternoclavicular_abduct	Up and down motion in the coronal plane	128	-240/ +60	-120/ +120
26	l_sternoclavicular_rotate	Rotation in the transverse plane	128	-120/ +120	-60/ +60
27	r_sternoclavicular_rotate	Rotation in the transverse plane	128	-120/ +120	-60/ +60
28	l_acromioclavicular_abduc t	Up and down motion in the coronal plane	128	-60/ +360	-120/ +120
29	r_acromioclavicular_abdu ct	Up and down motion in the coronal plane	128	-360/ +60	-120/ +120
30	l_acromioclavicular_rotate	Rotation in the transverse plane	128	-360/ +360	-120/ +120
31	r_acromioclavicular_rotate	Rotation in the transverse plane	128	-360/ +360	-120/ +120
32	l_shoulder_flexion	Forward-backward motion in the sagittal plane	64	-1080/ +1860	-600/ +600
33	r_shoulder_flexion	Forward-backward motion in the sagittal plane	64	-1080/ +1860	-600/ +600
34	l_shoulder_abduct	Sideward motion in the coronal plane	64	-240/ +1860	-600/ +600
35	r_shoulder_abduct	Sideward motion in the coronal plane	64	-1860/ +240	-600/ +600
36	l_shoulder_twisting	Rotation along the scapular axis	256	-960/ +960	-360/ +360
37	r_shoulder_twisting	Rotation along the scapular axis	256	-960/ +960	-360/ +360

38	l_elbow_flexion	Flexion-extension of the arm in the sagittal plane	64	-60/ +1560	-600/ +600
39	r_elbow_flexion	Flexion-extension of the arm in the sagittal plane	64	-60/ +1560	-600/ +600
40	l_elbow_twisting	Rotation of the forearm along the upper arm axis.	256	-960/ +960	-360/ +360
41	r_elbow_twisting	Rotation of the forearm along the upper arm axis.	256	-960/ +960	-360/ +360
42	l_wrist_flexion	Rotation of the hand in the coronal plane	128	-960/ +960	-600/ +600
43	r_wrist_flexion	Rotation of the hand in the coronal plane	128	-960/ +960	-600/ +600
44	l_wrist_pivot	Rotation of the hand in the sagittal planes	128	-660/ +660	-360/ +360
45	r_wrist_pivot	Rotation of the hand in the sagittal planes	128	-660/ +660	-360/ +360
46	l_wrist_twisting	Rotation of the hand along the forearm axis	256	-660/ +660	-360/ +360
47	r_wrist_twisting	Rotation of the hand along the forearm axis	256	-660/ +660	-360/ +360
48	skullbase_roll	Sideward motion of the skull along the frontal axis	128	-1860/ +1860	-600/ +600
49	skullbase_torsion	Twisting of the skull along the vertical axis	128	-1860/ +1860	-600/ +600
50	skullbase_tilt	Forward-backward motion in the sagittal plane along a lateral axis	128	-1860/ +1860	-600/ +600
51	vc1_roll	Sideward motion of vertebra C1	256	-240/ +240	-120/ +120
52	vc1_torsion	Twisting of vertebra C1	256	-240/ +240	-120/ +120
53	vc1_tilt	Forward-backward motion of vertebra C1 in the sagittal plane	256	-240/ +240	-120/ +120
54	vc2_roll	Sideward motion of vertebra C2	128	-660/ +660	-360/ +360
55	vc2_torsion	Twisting of vertebra C2	128	-660/ +660	-360/ +360
56	vc2_tilt	Forward-backward motion of vertebra C2 in the sagittal plane	128	-660/ +660	-360/ +360
57	vc3_roll	Sideward motion of vertebra C3	256	-240/ +240	-120/ +120
58	vc3_torsion	Twisting of vertebra C3	256	-240/ +240	-120/ +120

59	vc3_tilt	Forward-backward motion of vertebra C3 in the sagittal plane	256	-240/ +240	-120/ +120
60	vc4_roll	Sideward motion of vertebra C4	128	-660/ +660	-360/ +360
61	vc4_torsion	Twisting of vertebra C4	128	-660/ +660	-360/ +360
62	vc4_tilt	Forward-backward motion of vertebra C4 in the sagittal plane	128	-660/ +660	-360/ +360
63	vc5_roll	Sideward motion of vertebra C5	256	-240/ +240	-120/ +120
64	vc5_torsion	Twisting of vertebra C5	256	-240/ +240	-120/ +120
65	vc5_tilt	Forward-backward motion of vertebra C5 in the sagittal plane	256	-240/ +240	-120/ +120
66	vc6_roll	Sideward motion of vertebra C6	256	-240/ +240	-120/ +120
67	vc6_torsion	Twisting of vertebra C6	256	-240/ +240	-120/ +120
68	vc6_tilt	Forward-backward motion of vertebra C6 in the sagittal plane	256	-240/ +240	-120/ +120
69	vc7_roll	Sideward motion of vertebra C7	256	-240/ +240	-120/ +120
70	vc7_torsion	Twisting of vertebra C7	256	-240/ +240	-120/ +120
71	vc7_tilt	Forward-backward motion of vertebra C7 in the sagittal plane	256	-240/ +240	-120/ +120
72	vt1_roll	Sideward motion of vertebra T1	128	-660/ +660	-360/ +360
73	vt1_torsion	Twisting of vertebra T1	128	-660/ +660	-360/ +360
74	vt1_tilt	Forward-backward motion of vertebra T1 in the sagittal plane	128	-660/ +660	-360/ +360
75	vt2_roll	Sideward motion of vertebra T2	256	-240/ +240	-120/ +120
76	vt2_torsion	Twisting of vertebra T2	256	-240/ +240	-120/ +120
77	vt2_tilt	Forward-backward motion of vertebra T2 in the sagittal plane	256	-240/ +240	-120/ +120
78	vt3_roll	Sideward motion of vertebra T3	256	-240/ +240	-120/ +120
79	vt3_torsion	Twisting of vertebra T3	256	-240/ +240	-120/ +120

80	vt3_tilt	Forward-backward motion of vertebra T3 in the sagittal plane	256	-240/ +240	-120/ +120
81	vt4_roll	Sideward motion of vertebra T4	256	-240/ +240	-120/ +120
82	vt4_torsion	Twisting of vertebra T4	256	-240/ +240	-120/ +120
83	vt4_tilt	Forward-backward motion of vertebra T4 in the sagittal plane	256	-240/ +240	-120/ +120
84	vt5_roll	Sideward motion of vertebra T5	256	-240/ +240	-120/ +120
85	vt5_torsion	Twisting of vertebra T5	256	-240/ +240	-120/ +120
86	vt5_tilt	Forward-backward motion of vertebra T5 in the sagittal plane	256	-240/ +240	-120/ +120
87	vt6_roll	Sideward motion of vertebra T6	128	-660/ +660	-360/ +360
88	vt6_torsion	Twisting of vertebra T6	128	-660/ +660	-360/ +360
89	vt6_tilt	Forward-backward motion of vertebra T6 in the sagittal plane	128	-660/ +660	-360/ +360
90	vt7_roll	Sideward motion of vertebra T7	256	-240/ +240	-120/ +120
91	vt7_torsion	Twisting of vertebra T7	256	-240/ +240	-120/ +120
92	vt7_tilt	Forward-backward motion of vertebra T7 in the sagittal plane	256	-240/ +240	-120/ +120
93	vt8_roll	Sideward motion of vertebra T8	256	-240/ +240	-120/ +120
94	vt8_torsion	Twisting of vertebra T8	256	-240/ +240	-120/ +120
95	vt8_tilt	Forward-backward motion of vertebra T8 in the sagittal plane	256	-240/ +240	-120/ +120
96	vt9_roll	Sideward motion of vertebra T9	256	-240/ +240	-120/ +120
97	vt9_torsion	Twisting of vertebra T9	256	-240/ +240	-120/ +120
98	vt9_tilt	Forward-backward motion of vertebra T9 in the sagittal plane	256	-240/ +240	-120/ +120
99	vt_10roll	Sideward motion of vertebra T10	128	-660/ +660	-360/ +360
100	vt10_torsion	Twisting of vertebra T10	128	-660/ +660	-360/ +360

101	vt10_tilt	Forward-backward motion of vertebra T10 in sagittal plane	128	-660/ +660	-360/ +360
102	vt11_roll	Sideward motion of vertebra T11	256	-240/ +240	-120/ +120
103	vt11_torsion	Twisting of vertebra T11	256	-240/ +240	-120/ +120
104	vt11_tilt	Forward-backward motion of vertebra T11 in sagittal plane	256	-240/ +240	-120/ +120
105	vt12_roll	Sideward motion of vertebra T12	256	-240/ +240	-120/ +120
106	vt12_torsion	Twisting of vertebra T12	256	-240/ +240	-120/ +120
107	vt12_tilt	Forward-backward motion of vertebra T12 in sagittal plane	256	-240/ +240	-120/ +120
108	vl1_roll	Sideward motion of vertebra L1	128	-660/ +660	-360/ +360
109	vl1_torsion	Twisting of vertebra L1	128	-660/ +660	-360/ +360
110	vl1_tilt	Forward-backward motion of vertebra L1 in sagittal plane	128	-660/ +660	-360/ +360
111	vl2_roll	Sideward motion of vertebra L2	256	-240/ +240	-120/ +120
112	vl2_torsion	Twisting of vertebra L2	256	-240/ +240	-120/ +120
113	vl2_tilt	Forward-backward motion of vertebra L2 in sagittal plane	256	-240/ +240	-120/ +120
114	vl3_roll	Sideward motion of vertebra L3	128	-660/ +660	-360/ +360
115	vl3_torsion	Twisting of vertebra L3	128	-660/ +660	-360/ +360
116	vl3_tilt	Forward-backward motion of vertebra L3 in sagittal plane	128	-660/ +660	-360/ +360
117	vl4_roll	Sideward motion of vertebra L4	256	-240/ +240	-120/ +120
118	vl4_torsion	Twisting of vertebra L4	256	-240/ +240	-120/ +120
119	vl4_tilt	Forward-backward motion of vertebra L4 in sagittal plane	256	-240/ +240	-120/ +120
120	vl5_roll	Sideward motion of vertebra L5	128	-660/ +660	-360/ +360
121	vl5_torsion	Twisting of vertebra L5	128	-660/ +660	-360/ +360

122	vl5_tilt	Forward-backward motion of vertebra L5 in sagittal plane	128	-660/ +660	-360/ +360
123	l_pinky0_flexion	Metacarpal flexing mobility of the pinky finger	512	-240/ +240	-120/ +120
124	r_pinky0_flexion	Metacarpal flexing mobility of the pinky finger	512	-240/ +240	-120/ +120
125	l_pinky1_flexion	First knukle of the pinky finger	128	-1140/ +240	-240/ +240
126	r_pinky1_flexion	First knukle of the pinky finger	128	-1140/ +240	-240/ +240
127	l_pinky1_pivot	Lateral mobility of the pinky finger	128	-420/ +120	-120/ +120
128	r_pinky1_pivot	Lateral mobility of the pinky finger	128	-120/ +420	-120/ +120
129	l_pinky1_twisting	Along the pinky finger axis	256	-180/ +360	-120/ +120
130	r_pinky1_twisting	Along the pinky finger axis	256	-360/ +180	-120/ +120
131	l_pinky2_flexion	Second knuckle of the pinky number	128	-1380/ +60	-240/ +240
132	r_pinky2_flexion	Second knuckle of the pinky number	128	-1380/ +60	-240/ +240
133	l_pinky3_flexion	Third knuckle of the pinky finger	128	-960/ +60	-240/ +240
134	r_pinky3_flexion	Third knuckle of the pinky finger	128	-960/ +60	-240/ +240
135	l_ring0_flexion	Metacarpal flexing mobility of the ring finger	256	-180/ +180	-120/ +120
136	r_ring0_flexion	Metacarpal flexing mobility of the ring finger	256	-180/ +180	-120/ +120
137	l_ring1_flexion	First knukle of the ring finger	128	-1140/ +360	-240/ +240
138	r_ring1_flexion	First knukle of the ring finger	128	-1140/ +360	-240/ +240
139	l_ring1_pivot	Lateral mobility of the ring finger	128	-240/ +120	-120/ +120
140	r_ring1_pivot	Lateral mobility of the ring finger	128	-120/ +240	-120/ +120
141	l_ring1_twisting	Along the ring finger axis	256	-240/ +240	-120/ +120
142	r_ring1_twisting	Along the ring finger axis	256	-240/ +240	-120/ +120

143	l_ring2_flexion	Second knuckle of the ring number	128	-1380/ +60	-240/ +240
144	r_ring2_flexion	Second knuckle of the ring number	128	-1380/ +60	-240/ +240
145	l_ring3_flexion	Third knuckle of the ring finger	128	-960/ +60	-240/ +240
146	r_ring3_flexion	Third knuckle of the ring finger	128	-960/ +60	-240/ +240
147	l_middle0_flexion	Metacarpal flexing mobility of the middle finger	256	-120/ +120	-120/ +120
148	r_middle0_flexion	Metacarpal flexing mobility of the middle finger	256	-120/ +120	-120/ +120
149	l_middle1_flexion	First knukle of the middle finger	128	-1140/ +360	-240/ +240
150	r_middle1_flexion	First knukle of the middle finger	128	-1140/ +360	-240/ +240
151	l_middle1_pivot	Lateral mobility of the middle finger	128	-180/ +180	-120/ +120
152	r_middle1_pivot	Lateral mobility of the middle finger	128	-180/ +180	-120/ +120
153	l_middle1_twisting	Along the middle finger axis	256	-180/ +180	-120/ +120
154	r_middle1_twisting	Along the middle finger axis	256	-180/ +180	-120/ +120
155	l_middle2_flexion	Second knuckle of the middle number	128	-1380/ +60	-240/ +240
156	r_middle2_flexion	Second knuckle of the middle number	128	-1380/ +60	-240/ +240
157	l_middle3_flexion	Third knuckle of the middle finger	128	-960/ +60	-240/ +240
158	r_middle3_flexion	Third knuckle of the middle finger	128	-960/ +60	-240/ +240
159	l_index0_flexion	Metacarpal flexing mobility of the index finger	256	-60/ +60	-60/ +60
160	r_index0_flexion	Metacarpal flexing mobility of the index finger	256	-60/ +60	-60/ +60
161	l_index1_flexion	First knukle of the index finger	128	-1140/ +360	-240/ +240
162	r_index1_flexion	First knukle of the index finger	128	-1140/ +360	-240/ +240
163	l_index1_pivot	Lateral mobility of the index finger	128	-120/ +240	-60/ +60

164	r_index1_pivot	Lateral mobility of the index finger	128	-240/ +120	-60/ +60
165	l_index1_twisting	Along the index finger axis	256	-240/ +180	-120/ +120
166	r_index1_twisting	Along the index finger axis	256	-180/ +240	-120/ +120
167	l_index2_flexion	Second knuckle of the index number	128	-1380/ +60	-240/ +240
168	r_index2_flexion	Second knuckle of the index number	128	-1380/ +60	-240/ +240
169	l_index3_flexion	Third knuckle of the index finger	128	-960/ +60	-240/ +240
170	r_index3_flexion	Third knuckle of the index finger	128	-960/ +60	-240/ +240
171	l_thumb1_flexion	First knukle of the thumb finger	128	-480/ +960	-240/ +240
172	r_thumb1_flexion	First knukle of the thumb finger	128	-960/ +480	-240/ +240
173	l_thumb1_pivot	Lateral mobility of the thumb finger	128	-120/ +1080	-240/ +240
174	r_thumb1_pivot	Lateral mobility of the thumb finger	128	-1080/ +120	-240/ +240
175	l_thumb1_twisting	Along the thumb finger axis	256	-720/ +120	-240/ +240
176	r_thumb1_twisting	Along the thumb finger axis	256	-720/ +120	-240/ +240
177	l_thumb2_flexion	Second knuckle of the thumb number	128	-780/ +60	-240/ +240
178	r_thumb2_flexion	Second knuckle of the thumb number	128	-780/ +60	-240/ +240
179	l_thumb3_flexion	Third knuckle of the thumb finger	128	-960/ +60	-240/ +240
180	r_thumb3_flexion	Third knuckle of the thumb finger	128	-960/ +60	-240/ +240
181	HumanoidRoot_tr_vertical	Body origin translation in vertical direction	64	-1860/ +1860	-600/ +600
182	HumanoidRoot_tr_lateral	Body origin translation in lateral direction	64	-1860/ +1860	-600/ +600
183	HumanoidRoot_tr_frontal	Body origin translation in frontal direction	64	-1860/ +1860	-600/ +600

184	HumanoidRoot_rt_body_turn	Rotation of the skeleton root along the body coordinate system's vertical axis	64	-1860/ +1860	-600/ +600
185	HumanoidRoot_rt_body_roll	Rotation of the skeleton root along the body coordinate system's frontal axis	64	-1860/ +1860	-600/ +600
186	HumanoidRoot_rt_body_tilt	Rotation of the skeleton root along the body coordinate system's lateral axis	64	-1860/ +1860	-600/ +600

10. Annex 5: Suggested body joint center positions

These joint centre positions may be used to construct a “default” body.

HumanoidRoot	0.0000	0.9723	-0.0728
sacroiliac	0.0000	0.9710	-0.0728
l_hip	0.0956	0.9364	0.0000
l_knee	0.0956	0.5095	-0.0036
l_ankle	0.0946	0.0762	-0.0261
l_subtalar	0.0956	0.0398	0.0069
l_midtarsal	0.1079	0.0317	0.0670
l_metatarsal	0.0942	0.0092	0.1239
r_hip	-0.0956	0.9364	0.0000
r_knee	-0.0956	0.5095	-0.0036
r_ankle	-0.0946	0.0762	-0.0261
r_subtalar	-0.0956	0.0398	0.0069
r_midtarsal	-0.1079	0.0317	0.0670
r_metatarsal	-0.0942	0.0092	0.1239
vl5	0.0000	1.0817	-0.0728
vl4	0.0000	1.1174	-0.0727
vl3	0.0000	1.1525	-0.0727
vl2	0.0000	1.1795	-0.0727
vl1	0.0000	1.2161	-0.0727
vt12	0.0000	1.2527	-0.0727
vt11	0.0000	1.2918	-0.0727
vt10	0.0000	1.3098	-0.0737
vt9	0.0000	1.3375	-0.0752
vt8	0.0000	1.3631	-0.0758
vt7	0.0000	1.3875	-0.0745
vt6	0.0000	1.4116	-0.0712
vt5	0.0000	1.4351	-0.0657
vt4	0.0000	1.4569	-0.0587
vt3	0.0000	1.4832	-0.0482
vt2	0.0000	1.5011	-0.0397
vt1	0.0000	1.5201	-0.0300
vc7	0.0000	1.5382	-0.0213
vc6	0.0000	1.5607	-0.0073
vc5	0.0000	1.5770	-0.0012
vc4	0.0000	1.5912	-0.0014
vc3	0.0000	1.6050	-0.0033
vc2	0.0000	1.6178	-0.0033
vc1	0.0000	1.6394	0.0036
skullbase	0.0000	1.6440	0.0036
l_sternoclavicular	0.0757	1.4844	-0.0251
l_acromioclavicular	0.0899	1.4525	-0.0322
l_shoulder	0.1968	1.4642	-0.0265
l_elbow	0.1982	1.1622	-0.0557
l_wrist	0.1972	0.8929	-0.0690
l_thumb1	0.1912	0.8734	-0.0657
l_thumb2	0.1912	0.8156	-0.0079
l_thumb3	0.1912	0.8007	0.0070

l_index0	0.1912	0.8259	-0.0460
l_index1	0.1912	0.8050	-0.0460
l_index2	0.1912	0.7595	-0.0460
l_index3	0.1912	0.7370	-0.0460
l_middle0	0.1912	0.8282	-0.0710
l_middle1	0.1912	0.8071	-0.0710
l_middle2	0.1912	0.7525	-0.0710
l_middle3	0.1912	0.7263	-0.0710
l_ring0	0.1912	0.8302	-0.0972
l_ring1	0.1912	0.8098	-0.0972
l_ring2	0.1912	0.7570	-0.0972
l_ring3	0.1912	0.7328	-0.0972
l_pinky0	0.1912	0.8373	-0.1211
l_pinky1	0.1912	0.8173	-0.1211
l_pinky2	0.1912	0.7759	-0.1211
l_pinky3	0.1912	0.7584	-0.1211
r_sternoclavicular	-0.0757	1.4844	-0.0251
r_acromioclavicular	-0.0899	1.4525	-0.0322
r_shoulder	-0.1968	1.4642	-0.0265
r_elbow	-0.1982	1.1622	-0.0557
r_wrist	-0.1972	0.8929	-0.0690
r_thumb1	-0.1912	0.8734	-0.0657
r_thumb2	-0.1912	0.8156	-0.0079
r_thumb3	-0.1912	0.8007	0.0070
r_index0	-0.1912	0.8259	-0.0460
r_index1	-0.1912	0.8050	-0.0460
r_index2	-0.1912	0.7595	-0.0460
r_index3	-0.1912	0.7370	-0.0460
r_middle0	-0.1912	0.8282	-0.0710
r_middle1	-0.1912	0.8071	-0.0710
r_middle2	-0.1912	0.7525	-0.0710
r_middle3	-0.1912	0.7263	-0.0710
r_ring0	-0.1912	0.8302	-0.0972
r_ring1	-0.1912	0.8098	-0.0972
r_ring2	-0.1912	0.7570	-0.0972
r_ring3	-0.1912	0.7328	-0.0972
r_pinky0	-0.1912	0.8373	-0.1211
r_pinky1	-0.1912	0.8173	-0.1211
r_pinky2	-0.1912	0.7759	-0.1211
r_pinky3	-0.1912	0.7584	-0.1211

11. Annex A: The FAP file format

The MPEG-4 ASCII Facial Animation Parameters (FAP) file is used for storing and exchanging MPEG-4 facial animation data in an ASCII form.

Syntax:

```
# at the beginning of a line indicates a comment
[ Header ]
[ FAP Mask ]
[ Frame Number ] [ FAP Values ]
#the above two lines are repeated for each frame of animation
```

where:

```
[ Header ]
<float file format version> <string sequence name> <int frame rate> <int
number of frames>
[ FAP Mask ]
<int[68] FAP mask>
```

The FAP mask consists of 68 space-separated 1 or 0 digits. 1 indicates that a FAP is used in this particular frame, 0 indicates that it is not used. In the next line, after the frame number, values for all used FAPs are listed, space-separated.

```
[ Frame Number ]
<int frame number>
[ FAP Values ]
<int viseme_select1 0-14> <int viseme_select2 0-14> <int viseme_blend 0-63>
<int viseme_def 0-1> <int expression_select1 0-6> <int
expression_intensity1 0-63> <int expression_select2 0-6> <int
expression_intensity2 0-63> <int init_face 0-1> <int expression_def 0-1>
<int[] FAP values for used FAPs>
```

11.1 An example FAP file

The full file `emotions.fap` is available in the folder `Samples\ MPEG-4 ASCII Animation (.fap)`. Here is the extract of the file (an empty line space indicates a new line in order to distinguish from long lines that wrap):

```
#Header description

2.1 emotions 25 1050

0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

0 0 0 0 0 0 0 0 0 0 0 0 100 100 80 80 0 0 0 0 0 0 0 0 0 0 0 0

0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

1 0 0 0 0 0 0 0 0 0 0 0 100 100 80 80 0 0 0 0 0 0 0 0 0 0 0 0

0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

2 0 0 0 0 0 0 0 0 0 0 0 100 100 80 80 0 0 0 0 0 0 0 0 0 0 0 0
…
…
…
0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

1049 0 0 0 0 0 0 0 0 0 0 0 100 100 80 80 0 0 0 0 0 0 0 0 0 0 0 0
```

12. Annex B: The BAP file format

The MPEG-4 ASCII Body Animation Parameters (BAP) file is used for storing and exchanging MPEG-4 body animation data in an ASCII form.

Syntax:

```
# at the beginning of a line indicates a comment
[ Header ]
[ BAP Mask ]
[ Frame Number ] [ FAP Values ]
#the above two lines are repeated for each frame of animation
```

where:

```
[ Header ]
<float file format version> <string sequence name> <int frame rate> <int
number of frames>

[ BAP Mask ]
<int[296] BAP mask>
```

The BAP mask consists of 296 space-separated 1 or 0 digits. 1 indicates that a BAP is used in this particular frame, 0 indicates that it is not used. In the next line, after the frame number, values for all used BAPs are listed, space-separated.

```
[ Frame Number ]
<int frame number>

[ BAP Values ]
<int[] BAP values for used BAPs>
```

12.1 An example BAP file

Here is the extract of the file (an empty line space indicates a new line in order to distinguish from long lines that wrap):

```
#Header description

3.2 lit_a.bap 10 44

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0
1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

0 61086 -68067 64577 216420 -31415 -26179

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

1 -31415
```

13.Annex C: The EPF file format

The Encoder Parameter File is designed to give the encoder all the informations related to the corresponding FAP and BAP files, like I and P frames, masks, frame rate, quantization scaling factor and so on. The EPF file is necessary for encoding FAP and BAP files into binary MPEG-4 FBA bitstreams. The apparent complexity of the EPF file comes from the many options. However, in practical use, most of the time the default EPF file (given below as example) will work well and will only require adjusting the number of frames (this does not mean that it will achieve the best coding efficiency though).

Note: the mask defined in the EPF file overrides the mask defined in the corresponding FAP and BAP files.

The syntax is the following:

```
#comment to be skipped
FBM     <fba_paramset_mask 0-3> //each fba frame starts with this line
FFR     <face frame number as listed in FAP file> //only used if FBM&1
BFR     <body frame number as listed in BAP file> //only used if FBM&2
ISI     <is_intra>
FRR     <framerate 0-255> <seconds 0-15> <ntsc offset>
BRR     <framerate 0-255> <seconds 0-15> <ntsc offset>
TC      <timecode hours> <minutes> <markerbit> <seconds>
SKN     <number of frames to skip>
FMT     <group 1 fap_mask_type> <FAP group 1 mask if used> <group 2
fap_mask_type> ...<group 10 fap_mask_type> <FAP group 10 mask if used>
FQU     <fap_quant 0-31>
BQU     <bap_quant 0-31>
FIX     <FAP3 I max>... <FAP68 I max>
FIN     <FAP3 I min>... <FAP68 I min>
FPX     <FAP3 P max>... <FAP68 P max>
FPN     <FAP3 P min>... <FAP68 P min>
BIX     <BAP1 I max>... <BAP296 I max>
BIN     <BAP1 I min>... <BAP296 I min>
BPX     <BAP1 P max>... <BAP296 P max>
BPN     <BAP1 P min>... <BAP296 P min>
GDR     <gender bit (1=male, 0=female)>
CDM     <coding type (1=segment-based, 0=frame-based)>
```

The minimum entry for one frame is:

```
FBM 1
FRR <frame number as in the FAP file>
ISI 0/1   // for P or I frame respectively
```

Any combination of the remaining lines can be present ONLY in an I-frame (after ISI 1).

13.1 An example EPF file

The full file `emotions.epf` is available in the folder `Samples\Encoder Parameter Files (.epf)`. Here is the extract of the file:

```
# EPF file for integration of Marco30 & welcome sequences
# EPFL - Tolga Capin
# January 5, 1999
#
FBM 3
FFR 0
BFR 0
ISI 1
FRR 30 0 0
FMT 0   2 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0  2 1 1 1 1 1 1 1 1 0 0 0 0  3  0
0  3  3  0  0
FQU 2
FIX 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 840 840
600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600
600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600
600 600 600 600 600 600 600 600 600 600
FIN -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -
600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -600 -
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BRR 25 0 0
BMT 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 0 0 0 0 0
BQU 1
BIX 1859 1859 1859 1859 1859 1859 1859 1859 1859 1859 1859 1859 1859 1859
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```

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ISI 0
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ISI 0
FBM 3
FFR 5
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