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A. Appendix I: Definitions and notation

Coordinate system

A left handed world coordinate system is used throughout this document. Using the left hand, pointing forward with the index finger and upward with the thumb, and bending the middle finger to the right, the x, y, and z axis are formed. This is shown graphically in figure A-1.

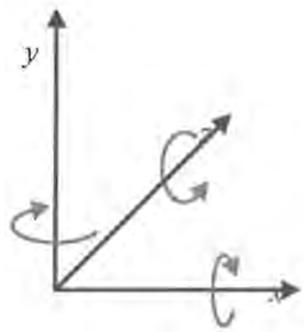

Figure A-1: Left handed coordinate system

The curl of the left hand fingers shows the direction of positive rotation with the thumb pointing in the direction of the desired axis. Figure A-1 also depicts the positive angle direction around each axis.

Vectors

A vector space consists of a set of elements, called *vectors*, together with the addition operator and the scalar multiplication operation. In this text we will use the vector space $\mathbf{R}^3$ or $\mathbf{R}^4$, the set of all ordered 3 or 4-tuples of real numbers. A vector is denoted by boldface letters, such as $\mathbf{u}$, $\mathbf{v}$ or $\mathbf{w}$. A vector in $\mathbf{R}^3$ consists of three elements, which is conveniently denoted by x, y and z. Vectors in $\mathbf{R}^4$ contains one additional component. Vector components are written horizontally in row format as

$[x\ y\ z]$

which differs from some texts [65] which uses the vertical column format method

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} \text{ or } [x\ y\ z]^T.$$

The following vector operations are used in this text:

Multiplication by a scalar:	$\mathbf{v} = \mathbf{u}s$
Addition:	$\mathbf{w} = \mathbf{u}+\mathbf{v}$
Dot product:	$s = \mathbf{u} \cdot \mathbf{v}$
Cross product:	$\mathbf{w} = \mathbf{u} \times \mathbf{v}$
Vector length:	$s = \lVert \mathbf{u} \rVert$
Vector transpose:	$\mathbf{v} = \mathbf{u}^T$

Matrices

A matrix is a rectangular array of real values. A matrix is denoted by a boldface capital letter such as **A**, **B** or **M**. Its elements are doubly indexed, with the first index indicating the row and the second index the column. A 4x4 matrix is therefore written as

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix}.$$

The following matrix operations are used in this text:

Matrix multiplication:	$\mathbf{C} = \mathbf{AB}$
Matrix inverse:	$\mathbf{B} = \mathbf{A}^{-1}$
Matrix transpose:	$\mathbf{B} = \mathbf{A}^{\mathrm{T}}$
Vector-matrix multiplication:	$\mathbf{v} = \mathbf{uA}$
Matrix-vector multiplication:	$\mathbf{v}^{\mathrm{T}} = \mathbf{Au}^{\mathrm{T}}$

The *identity matrix* is denoted by **I**. The *homogeneous transformation matrix* is a special 4x4 matrix that has the following form:

$$\mathbf{A} = \begin{bmatrix} r_{xx} & r_{xy} & r_{xz} & 0 \\ r_{yx} & r_{yy} & r_{yz} & 0 \\ r_{zx} & r_{zy} & r_{zz} & 0 \\ t_x & t_y & t_z & 1 \end{bmatrix},$$

or more compactly

$$\mathbf{A} = \begin{bmatrix} \mathbf{R} & \mathbf{0} \\ \mathbf{t} & 1 \end{bmatrix},$$

where $\mathbf{R}$ is a 3x3 rotation matrix, $\mathbf{t}$ is a translation vector in $\mathbf{R}^3$ and $\mathbf{0}$ is the zero vector [0 0 0]. The 1x3 row vectors of $\mathbf{R}$ are orthonormal and contains the x, y, and z axis of rotation respectively. If and only if we are using a transformation matrix, the inverse is conveniently given by

$$\mathbf{A}^{-1} = \begin{bmatrix} \mathbf{R}^{\mathrm{T}} & \mathbf{0} \\ -\mathbf{tR}^{\mathrm{T}} & 1 \end{bmatrix}.$$

The notation $\mathbf{R}(\mathbf{u}, \theta)$ or $\mathbf{R}(u_x, u_y, u_z, \theta)$ defines a rotation matrix around the axis $\mathbf{u}$ of θ degrees and is given by

$$\mathbf{R}(\mathbf{u},\theta)=\begin{bmatrix} u_x^2+\mathrm{c}(1-u_x^2) & u_xu_y(1-\mathrm{c})+u_z\mathrm{s} & u_xu_z(1-\mathrm{c})+u_y\mathrm{s} & 0 \\ u_xu_y(1-\mathrm{c})+u_z\mathrm{s} & u_y^2+\mathrm{c}(1-u_y^2) & u_yu_z(1-\mathrm{c})+u_x\mathrm{s} & 0 \\ u_xu_z(1-\mathrm{c})-u_y\mathrm{s} & u_yu_z(1-\mathrm{c})+u_x\mathrm{s} & u_z^2+\mathrm{c}(1-u_z^2) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

where c = cos(θ) and s = sin(θ). If we rotate around one of the primary axis x, y or z, a convenient short hand notation is $\mathbf{R}(1, 0, 0, \theta) = \mathbf{R}_x(\theta)$, $\mathbf{R}(0, 1, 0, \theta) = \mathbf{R}_y(\theta)$ and $\mathbf{R}(0, 0, 1, \theta) = \mathbf{R}_z(\theta)$.

Similarly, the notation $\mathbf{T}(\mathbf{u})$ or $\mathbf{T}(u_x, u_y, u_z)$ defines a translation matrix and is given by

$$\mathbf{T}=\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ u_x & u_y & u_z & 1 \end{bmatrix}.$$

Variables and equations

General variables or degrees of freedom (DOFs) are represented by the symbol θ. A specific DOF is specified by the symbol $\theta_{i,j}$, where i is a zero-based integer representing either a joint or a group number, depending on the context. The zero-based integer j represents the DOF within the joint or group. The subscript i,j is sometimes omitted for clarity, in which case it can be assumed that θ represents *any* DOF. DOFs are functions of time, and can be written as $\theta(t)$. Since we are dealing with discrete time sampled quantities in practice, a *single* sample is written as $\theta(n)$. A *sequence* of samples is written as $\{\theta(n)\}$. For convenience, some expressions use a continuous time representation, while others use a discrete time representation.

Proofs

The following terminology is helpful:

- Proof by mutual consent

"We can show that..."

- Proof by vagueness

"It can be shown that..."

- Proof by intimidation

"It is understood that..."

B. Appendix II: Dynamic simulation

The purpose of dynamic simulation is to generate realistic animation using forces and torques calculated from physical laws. The process can be divided into two parts, namely forward dynamics and inverse dynamics. Forward dynamics simply use the forces and torques at each joint to *generate* motion. Inverse dynamics *calculate* the required forces and torques to generate the desired motion. These two processes are therefore related and dependent on each other. The forward and inverse dynamics problem has been extensively studied in the robotics field. See [69] for a good overview of these algorithms. Dynamic formulations range from non-recursive $O(N^4)$ algorithms to recursive $O(N)$ algorithms, where N is the number of DOFs. An example of an efficient recursive solution is the Armstrong-Green algorithm [10,69], which is based on the Newton-Euler formulations of motion. This algorithm is summarized as follows:

Scalars

m_i	Mass of the *i*th segment
nd_i	Number of DOFs at the *i*th joint
$\dot{\theta}_{i,j}$	First derivative of the *j*th DOF of the *i*th joint
$\ddot{\theta}_{i,j}$	Second derivative of the *j*th DOF of the *i*th joint

Vectors

ω^i Angular velocity of the *i*th segment

α^i Angular acceleration of the *i*th segment

$\mathbf{a}^i$ Linear acceleration of the *i*th segment at its pivot point

$\mathbf{a}_c^i$ Linear acceleration of the *i*th segment at its center of mass

$\mathbf{g}$ Acceleration due to gravity [0 –10 0] m/s^2

$\mathbf{g}_i$ Gravitation of the *i*th segment

$\mathbf{f}_i$ Force exerted on the *i*th segment by the (*i*-1)th segment

$\mathbf{n}_i$ Moment exerted on the *i*th segment by the (*i*-1)th segment

τ_i Generalized actuator torque at the *i*th joint

$\mathbf{p}_i$ Vector from the pivot point of the *i*th segment to the (*i*+1)th segment

$\mathbf{s}_i$ Vector from the pivot point of the *i*th segment to its center of mass

$\mathbf{z}_{i,j}$ Axis of rotation for the *j*th DOF of the *i*th joint

$\mathbf{F}_i$ Total force on the *i*th segment

$\mathbf{N}_i$ Total external torque on the *i*th segment

Matrices

$\mathbf{J}_i$ Inertia tensor of the *i*th segment

$\mathbf{A}_i^j$ Rotational matrix from the *j*th segment to the *i*th segment

Recursion initialization

$$\boldsymbol{\omega}^0 = 0$$

$$\boldsymbol{\alpha}^0 = 0$$

$$\mathbf{f}_{n+1} = \textit{Force at end-effector}$$

$$\mathbf{n}_{n+1} = \textit{Moment at end-effector}$$

Forward recursion

for $i = 1 \ldots n$ do

$$\boldsymbol{\omega}^i = \mathbf{A}_i^{i-1}\boldsymbol{\alpha}^{i-1} + \sum_{j=1}^{nd_i} \mathbf{z}_{i,j}\dot{\theta}_{i,j}$$

$$\boldsymbol{\alpha}^i = \mathbf{A}_i^{i-1}\boldsymbol{\alpha}^{i-1} + \sum_{j=1}^{nd_i} \mathbf{z}_{i,j}\ddot{\theta}_{i,j} + \mathbf{A}_i^{i-1}\boldsymbol{\omega}^{i-1} \times \sum_{j=1}^{nd_i} \mathbf{z}_{i,j}\dot{\theta}_{i,j}$$

$$\mathbf{a}^i = \mathbf{A}_i^{i-1}\left(\mathbf{a}^{i-1} + \boldsymbol{\alpha}^{i-1} \times \mathbf{p}_{i-1} + \boldsymbol{\omega}^{i-1} \times \left(\boldsymbol{\omega}^{i-1} \times \mathbf{p}_{i-1}\right)\right)$$

$$\mathbf{a}_c^i = \mathbf{a}^i + \boldsymbol{\alpha}^i \times \mathbf{s}_i + \boldsymbol{\omega}^i \times \left(\boldsymbol{\omega}^i \times \mathbf{s}_i\right)$$

$$\mathbf{g}_i = \mathbf{A}_i^0\left(m_i\mathbf{g}\right)$$

$$\mathbf{F}_i = m_i\mathbf{a}_c^i$$

$$\mathbf{N}_i = \mathbf{J}_i\boldsymbol{\alpha}^i + \boldsymbol{\omega}^i \times \mathbf{J}_i\boldsymbol{\omega}^i$$

Backward recursion

for $i = 1 \ldots n$ do

$$\mathbf{f}_i = \mathbf{F}_i + \mathbf{A}_i^{i+1}\mathbf{f}_{i+1} - \mathbf{g}_i$$

$$\mathbf{n}_i = \mathbf{N}_i + \mathbf{A}_i^{i+1}\mathbf{n}_{i+1} + \mathbf{s}_i \times \left(\mathbf{F}_i - \mathbf{g}_i\right) + \mathbf{p}_i \times \mathbf{A}_i^{i+1}\mathbf{f}_{i+1}$$

$$\tau_i = \mathbf{n}_i \cdot \mathbf{z}_i$$

C. Appendix III: CD-ROM contents

The visual results of this study are supplied on CD-ROM as video clips. The video clips all have a resolution of 368x272 pixels and are compressed with the MPEG-1 format. The CD-ROM disk is organized in a number of directories, each containing the results for a specific coding method. The following directories are provided:

Directory name	Description
`Original`	Original test sequences
`Quantization`	Straight joint quantization
`Predictive`	Predictive coding
`AdaptivePredictive`	Adaptive predictive coding
`DeadReckoning`	Dead reckoning coding
`Transform`	DCT based coding
`SpatialVQ`	Spatial vector quantization
`TemporalVQ`	Temporal vector quantization
`PostureBased`	Posture based coding
`GestureBased`	Gesture based coding
`Hybrid`	Waveform/model based hybrid coding

Four test sequences, namely the conversation, wave, dance and gesture sequences, are used for each coding method. Each directory contains the following files (excluding the directory `Original`):

File name	Description
`Readme.txt`	General information
`Conver.rd`	Rate-distortion information for the conversation sequence
`Conver?.mpg`	MPEG video clips for the conversation sequence
`Wave.rd`	Rate-distortion information for the wave sequence
`Wave?.mpg`	MPEG video clips for the wave sequence

`Dance.rd`	Rate-distortion information for the dance sequence
`Dance?.mpg`	MPEG video clips for the dance sequence
`Gestur.rd`	Rate-distortion information for the gesture sequence
`Gestur?.mpg`	MPEG video clips for the gesture sequence

The "?" wildcard is a single digit zero-based integer index that is an indication of the coding parameters that were used to obtain the sequence. The rate-distortion files contain a list of bit-rates and signal-to-noise ratios in the *same order* as the index. The units of the rate quantity are [bits/second] and the distortion quantity [dB]. The relevant coding parameters and rate-distortion results for each directory (compression method) are as follows:

Quantization

Coding parameters:

Index	Number of quantization levels
0	8
1	16
2	32
3	64
4	128
5	256

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	PSNR	Rate	PSNR	Rate	PSNR	Rate	PSNR
0	4454.8	9.9	4338.0	10.2	4397.3	10.2	973.7	16.4
1	6135.6	16.7	5891.7	16.5	6038.4	16.9	1283.6	22.9
2	7812.9	23.0	7402.1	23.1	7692.0	23.2	1605.0	29.3
3	9476.0	29.1	8912.4	29.0	9319.5	29.3	1945.0	35.4
4	11062.1	35.2	10281.1	35.1	10872.1	35.3	2275.5	41.7
5	12526.4	41.3	11511.0	41.2	12288.1	41.3	2576.3	47.6

Predictive

Coding parameters:

Index	Number of difference quantization levels
0	4
1	8
2	16
3	32
4	64
5	128
6	256

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	PSNR	Rate	PSNR	Rate	PSNR	Rate	PSNR
0	2356.5	13.4	2428.8	11.2	2555.6	10.4	479.3	14.0
1	3548.7	24.1	3750.9	21.6	3948.5	20.4	607.7	23.6
2	5285.1	31.1	5421.1	28.7	5648.1	27.4	792.9	30.6
3	7090.6	38.1	7168.0	35.1	7393.8	33.9	1074.8	36.5
4	8897.8	44.7	8886.5	41.7	9114.0	40.0	1416.5	43.5
5	10594.6	51.0	10438.5	47.8	10742.8	46.5	1756.8	49.6
6	12141.0	57.3	11774.9	54.3	12246.7	52.4	2120.8	56.3

AdaptivePredictive

Coding parameters:

Index	Number of difference quantization levels
0	4
1	8
2	16
3	32
4	64
5	128
6	256

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	PSNR	Rate	PSNR	Rate	PSNR	Rate	PSNR
0	2939.8	10.7	2734.6	9.0	2984.4	8.0	574.0	10.7
1	3325.4	23.2	3395.8	21.2	3572.4	20.1	700.9	21.7
2	4048.2	31.4	4482.6	28.8	4623.4	27.9	838.4	29.2
3	5267.9	38.7	5891.8	36.0	6036.2	34.9	1008.0	35.9
4	6784.6	44.1	7421.6	42.8	7562.5	41.5	1262.7	42.7

5	8348.6	50.6	8882.1	48.8	9074.5	48.0	1531.2	49.4
6	9833.7	58.7	10167.9	55.9	10470.6	52.9	1836.6	56.3

DeadReckoning

Coding parameters:

Sequence Index	Conversation/Wave error threshold ε [deg]	Dance/Gesture error threshold ε [deg]
0	1.6	16
1	0.8	8
2	0.4	4
3	0.2	2
4	0.1	1
5	0.05	0.5
6	0.025	0.25
7	0.0125	0.125

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	PSNR	Rate	PSNR	Rate	PSNR	Rate	PSNR
0	2567.3	4.4	1711.9	2.1	1164.3	-2.9	187.3	6.2
1	4049.3	9.2	2887.6	5.9	2392.6	2.3	306.7	12.1
2	5967.0	13.5	4678.5	8.7	4080.8	7.9	500.5	18.2
3	8344.5	18.3	6837.5	11.8	6175.2	14.3	815.2	24.6
4	10884.5	22.4	9071.5	17.8	8552.3	21.0	1223.3	30.8
5	13048.7	28.0	11184.5	23.7	11336.7	27.5	1671.2	36.8
6	14996.4	33.1	13196.9	29.3	14156.0	34.0	2227.2	43.0
7	16140.5	35.5	14420.9	31.9	16270.9	39.5	2743.7	48.7

Transform

Coding parameters:

Index	Quantizer bits	Normalized speed threshold
0	8, 7, 7, 6, 6, 5, 4, 4, 3, 3, 2, 2, 0, 0, 0, 0	0.9, 0.92, 0.94, 0.98, 1
1	8, 7, 6, 5, 5, 4, 4, 3, 3, 2, 2, 0, 0, 0, 0, 0	0.7, 0.75, 0.8, 0.85, 0.9
2	7, 6, 5, 4, 4, 3, 3, 3, 2, 2, 0, 0, 0, 0, 0, 0	0.3, 0.4, 0.5, 0.6, 0.8
3	6, 5, 4, 4, 3, 3, 2, 2, 0, 0, 0, 0, 0, 0, 0, 0	0.1, 0.2, 0.3, 0.4, 0.6
4	5, 4, 3, 3, 2, 2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0	0.05, 0.1, 0.2, 0.3, 0.4

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	PSNR	Rate	PSNR	Rate	PSNR	Rate	PSNR
0	1669.5	20.0	1558.4	18.1	1653.9	15.7	331.4	22.0
1	2507.8	24.8	2353.7	21.1	2496.9	20.4	486.9	27.6
2	3295.5	28.3	3121.4	24.4	3293.6	22.5	629.4	31.1
3	4019.4	30.5	3742.2	25.8	4022.3	23.7	757.2	33.5
4	4784.7	31.1	4475.1	27.1	4797.9	24.1	920.1	34.5

SpatialVQ

Coding parameters:

Index	Number of VQ codebook entries
0	16
1	32
2	64
3	128
4	256
5	512

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	PSNR	Rate	PSNR	Rate	PSNR	Rate	PSNR
0	747.3	-0.8	725.5	-1.1	789.1	0.2	86.8	4.9
1	959.6	0.5	915.9	1.8	969.0	1.2	98.4	9.8
2	1519.1	1.7	1106.5	4.3	1156.4	2.8	106.2	12.1
3	2145.1	3.2	1331.3	8.0	1331.2	4.2	130.9	14.9
4	2569.6	4.6	1558.1	11.7	1494.5	6.0	148.4	16.7
5	2910.3	6.1	1805.6	16.0	1645.9	7.9	167.5	18.7

TemporalVQ

Coding parameters:

Index	Number of VQ codebook entries
0	16
1	32
2	64
3	128
4	256
5	512

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	PSNR	Rate	PSNR	Rate	PSNR	Rate	PSNR
0	988.4	7.5	937.6	7.6	1005.9	5.8	189.9	13.9
1	1254.7	10.0	1200.6	10.3	1236.2	8.1	229.5	16.7
2	1586.8	12.7	1551.8	14.7	1469.6	10.3	281.2	19.4
3	1972.5	15.3	2274.1	25.4	1666.1	12.5	321.9	21.2
4	2412.3	18.4	2593.3	30.3	1908.5	15.1	398.8	24.4
5	2906.4	22.0	2833.1	32.8	2301.2	17.5	494.2	28.1

PostureBased

Coding parameters:

Index	Sampling distance *d*
0	80
1	40
2	26.6667
3	20
4	16
5	13.3333
6	10

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	VPSNR	Rate	VPSNR	Rate	VPSNR	Rate	VPSNR
0	20.9	6.8	19.5	3.6	67.7	3.8	7.4	13.1
1	55.2	9.1	43.7	6.2	191.2	6.5	17.9	15.2
2	88.4	10.7	69.8	8.2	317.2	7.3	28.1	16.9
3	124.5	11.6	94.7	9.3	440.5	7.5	40.2	18.4
4	156.7	12.1	118.1	9.8	566.8	7.8	50.1	19.7
5	192.1	12.5	144.8	10.2	666.5	8.2	58.6	20.9
6	225.5	12.9			762.8	8.5	70.0	21.8

GestureBased

Abbreviations:

nWin	Length of threshold filter
β	Initial value of β (before recursion)
nMin	Minimum number of samples per segment
nMax	Maximum number of samples per segment
D	Gesture table similarity discard distance
E	Gesture fit distance
b	Error weigthing constant *b* (*a* is always 1)
nNorm	Number of samples in normalized or warped segment
nBlend	Number of samples that can be used for blending

Parameters for coding of conversation sequence:

Param. Group	*nWin*	β	*nMin*	*nMax*	*D*	*E*	*b*	*nNorm*	*nBlend*
0	20	0.75	5	60	1	1	1	60	10
1	20	0.75	5	60	1	1	1	60	10
2	20	0.75	5	60	5	5	0.5	60	10
3	20	0.75	5	60	5	5	0.5	60	10
4	20	0.75	5	60	5	5	0.5	60	10
5	20	0.75	5	60	5	5	0.5	60	10
6	20	0.75	5	60	2	2	0.5	60	10
7	20	0.75	5	60	2	2	0.5	60	10

Parameters for coding of wave sequence:

Param. Group	*nWin*	β	*nMin*	*nMax*	*D*	*E*	*b*	*nNorm*	*nBlend*
0	20	0.75	5	60	1	1	1	60	10
1	20	0.75	5	60	1	1	1	60	10
2	20	0.75	5	60	10	10	0.5	60	10
3	20	0.75	5	60	5	5	0.5	60	10
4	20	0.75	5	60	10	10	0.5	60	10
5	20	0.75	5	60	5	5	0.5	60	10
6	20	0.75	5	60	2	2	0.5	60	10
7	20	0.75	5	60	2	2	0.5	60	10

Parameters for coding of dance sequence:

Param. Group	*nWin*	β	*nMin*	*nMax*	*D*	*E*	*b*	*nNorm*	*nBlend*
0	20	0.75	3	30	5	5	1	30	10
1	20	0.75	3	30	5	5	1	30	10
2	20	0.75	3	30	15	15	0.75	30	10
3	20	0.75	3	30	10	10	0.75	30	10
4	20	0.75	3	30	15	15	0.75	30	10
5	20	0.75	3	30	10	10	0.75	30	10
6	20	0.75	3	30	5	5	0.75	30	10
7	20	0.75	3	30	5	5	0.75	30	10

Parameters for coding of gesture sequence:

Param. Group	*nWin*	β	*Nmin*	*nMax*	*D*	*E*	*b*	*nNorm*	*nBlend*
0	20	0.75	5	60	1	1	1	60	10
1	20	0.75	5	60	1	1	1	60	10
2	20	0.75	5	60	5	5	0.5	60	10
3	20	0.75	5	60	10	10	0.25	60	10
4	20	0.75	5	60	5	5	0.5	60	10
5	20	0.75	5	60	10	10	0.25	60	10
6	20	0.75	5	60	2	2	0.5	60	10
7	20	0.75	5	60	2	2	0.5	60	10

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	VPSNR	Rate	VPSNR	Rate	VPSNR	Rate	VPSNR
0	82.1	5.8	59.1	3.5	145.1	4.1	5.8	10.5
1	89.5	6.5	59.0	3.5	165.5	5.5	5.8	10.5
2	105.5	8.5	65.4	4.9	214.3	7.8	7.2	11.6
3	140.8	12.3	82.2	8.2	293.3	11.5	11.1	14.8
4	155.8	14.1	96.5	10.9	310.2	12.4	13.1	16.3
5	167.3	15.3	109.6	12.3	336.7	13.3	14.9	17.6

Hybrid

Coding parameters:

Index	Coeff. 0 [bits]	Coeff. 1 [bits]	Coeff. 2 [bits]
0	4	3	2
1	4	4	2
2	5	4	3
3	5	5	3
4	6	5	4
5	6	6	4
6	7	6	5
7	7	7	5

Rate-distortion results:

Sequence Index	Conversation		Wave		Dance		Gestures	
	Rate	VPSNR	Rate	VPSNR	Rate	VPSNR	Rate	VPSNR
0	395.4	11.2	380.0	7.3	749.7	10.8	109.6	17.1
1	532.5	13.5	492.6	10.2	1034.0	13.7	141.6	18.0
2	622.7	14.4	564.9	11.1	1194.5	15.0	165.0	18.1
3	690.7	14.7	619.6	11.8	1313.0	15.7	181.9	18.3
4	746.0	15.0	654.6	12.1	1413.5	16.2	194.3	18.3
5	785.1	15.4	691.3	12.5	1497.2	16.5	202.6	18.4
6	820.8	15.6	718.2	12.8	1573.2	16.7	211.5	18.4
7	849.5	15.7	743.9	12.9	1640.3	16.9	217.1	18.4