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D E C I S I O N
of 28 March 2006

Case Number: T 0198/04 - 3.5.02

Application Number: 97300068.0

Publication Number: 0785631

IPC: H03M 7/00

Language of the proceedings: EN

Title of invention:

Perceptual noise shaping in the time domain via LPC prediction
in the frequency domain

Applicant:

LUCENT TECHNOLOGIES INC.

Opponent:

-

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step - after amendment (yes) "

Decisions cited:

T 1194/97

Catchword:

-



Case Number: T 0198/04 - 3.5.02

D E C I S I O N
of the Technical Board of Appeal 3.5.02
of 28 March 2006

Appellant: LUCENT TECHNOLOGIES INC.
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Representative: Sarup, David Alexander
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 22 September 2003
refusing European application No. 97300068.0
pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: J.-M. Cannard
C. Holtz

Summary of Facts and Submissions

I. The appellant contests the decision of the examining division to refuse European patent application No. 97 300 068.0. The reason given for the refusal was that the subject-matter of all the claims as originally filed, then the claims under examination, were obvious to the skilled person having regard to the acknowledged prior art.

II. The documents:

D1: J. Proakis: "Digital Communications", 3rd edition 1995, pages 125 to 133,

D2: R. Steele: "Mobile Radio Communications", 1992, pages 186 to 191,

D3: Pennebaker and Mitchell, "JPEG Still Image Compression Standard", Van Nostrand Reinhold, 1993, pages 65 to 73, and

D4: Tribolet and Crochiere: "Frequency Domain Coding of Speech", IEEE Transactions on Acoustics, Speech, and Signal Processing, vol. ASSP-27, No. 5, 1979, pages 512 to 530,

considered in the first instance proceedings, remain relevant to the present appeal.

III. Independent claims 1, 7, 11, 15 and 17 of the set of amended claims according to the current request, which was filed during the oral proceedings held on 28 March 2006, read as follows:

Claim 1:

"A method of encoding an audio signal to generate an encoded signal, the encoding based on a perceptual model, the method comprising the steps of:

(a) performing a spectral decomposition of the audio signal into a plurality of spectral component signals;

(b) generating a prediction signal representative of a prediction of one of said spectral component signals, said prediction based on one or more other ones of said spectral component signals, said prediction being performed across the frequency domain;

(c) comparing the prediction signal with said one of said spectral component signals to generate a prediction error signal;

(d) coding said one of said spectral component signals to generate a coded spectral component signal, said coding based on the prediction error signal and further based on the perceptual model; and

(e) generating the encoded signal based on the coded spectral component signal."

Claim 7:

"A method of decoding an encoded audio signal to generate a reconstructed audio signal, the encoded signal comprising a plurality of coded spectral component signals having been encoded based on a

perceptual model, the method comprising the steps of:

- (a) decoding a first one of said coded spectral component signals;
- (b) generating a prediction signal representative of a prediction of a second one of said spectral component signals, said prediction based on the decoding of the first one of said coded spectral component signals, said prediction being performed across the frequency domain;
- (c) decoding the second one of said spectral component signals based on the prediction signal; and
- (d) generating the reconstructed audio signal based on the decoding of the first one of said coded spectral component signals and on the decoding of the second one of said coded spectral component signals."

Claim 11:

"An encoder for generating an encoded signal from an audio signal, the encoding based on a perceptual model, the encoder comprising:

- (a) means for decomposing the audio signal into a plurality of spectral component signals;
- (b) means for generating a prediction signal representative of a prediction of one of said spectral component signals, said prediction based on one or more other ones of said spectral component signals, said prediction being performed across the frequency domain;

(c) means for comparing the prediction signal with said one of said spectral component signals to generate a prediction error signal;

(d) a coder for generating a coded spectral component signal representative of said one of said spectral component signals, said coded spectral component signal generated based on the prediction error signal and further based on the perceptual model; and

(e) means for generating the encoded signal based on the coded spectral component signal."

Claim 15:

"A decoder for generating a reconstructed audio signal from an encoded audio signal, the encoded audio signal comprising a plurality of coded spectral component signals having been encoded based on a perceptual model, the decoder comprising:

(a) means for decoding a first one of said coded spectral component signals;

(b) means for generating a prediction signal representative of a prediction of a second one of said spectral component signals, said prediction based on the decoding of the first one of said coded spectral component signals, said prediction being performed across the frequency domain;

(c) means for decoding the second one of said spectral component signals based on the prediction signal; and

(d) means for generating the reconstructed audio signal based on the decoding of the first one of said coded spectral component signals and on the decoding of the second one of said coded spectral component signals."

Claim 17:

"A storage medium having an encoded audio signal recorded thereon, the encoded audio signal having been generated from an audio signal by an encoding method based on a perceptual model and comprising the steps of:

(a) performing a spectral decomposition of the audio signal into a plurality of spectral component signals;

(b) generating a prediction signal representative of a prediction of one of said spectral component signals, said prediction based on one or more other ones of said spectral component signals, said prediction being performed across the frequency domain;

(c) comparing the prediction signal with said one of said spectral component signals to generate a prediction error signal;

(d) coding said one of said spectral component signals to generate a coded spectral component signal, said coding based on the prediction error signal and further based on the perceptual model; and

(e) generating the encoded audio signal based on the coded spectral component signal."

Claims 2 to 6 are dependent on claim 1. Claims 8 to 10 are dependent on claim 7. Claims 12 to 14 are dependent on claim 11. Claim 16 is dependent on claim 15. Claims 18 to 24 are dependent on claim 17.

IV. The arguments of the appellant can be summarized as follows:

The methods and apparatus for encoding or decoding an audio signal according to the current request were based on a perceptual model and on a predictive filtering performed across the frequency domain, as this appeared more specifically from the expression "said prediction being performed across the frequency domain", which was included in independent claims 1, 7, 11, 15 and 17. As a result of this prediction, a noise shaping was achieved in the time domain and the temporal spread of quantization noise was reduced.

The encoding or decoding of an audio signal by applying predictive filtering across a plurality of different spectral component coefficients of the audio signal for the same period of time, as in the invention, was neither disclosed nor suggested by the cited prior art. In documents D1 and D2, a predictive filtering was performed across a plurality of signal samples taken in series in the time domain, and, in document D3, the filtering was performed across a plurality of signal samples of an image taken in space. The sub-band coders disclosed in document D4 suggested a possible use of predictive coding techniques, as for instance an ADPCM coding, but as in all of the predictive filters known from the prior art, the prediction was performed across time on data belonging to a given frequency sub-band.

The transform coders described in D4 did not suggest any form of prediction at all.

- V. The appellant requested that the decision under appeal be set aside and that a patent be granted in the following version:

claims 1 to 24 filed in the oral proceedings,
description: pages 1 to 3 and 5 to 14 as originally
filed and pages 4 and 4A filed with letter of 17 March
2006,

drawings: figures 1 to 7 as originally filed.

Reasons for the Decision

1. The appeal is admissible.

Admissibility of amendments

2. The Board is satisfied that the claims and the description according to the current request meet the requirements of Article 84 EPC and do not contravene Article 123(2) EPC.

- 2.1 This applies in particular to independent claims 1, 7, 11, 15 and 17, which respectively differ from the independent claims 1, 7, 11, 15 and 17 as originally filed by the incorporation of the additional feature "said prediction being performed across the frequency domain". This additional feature is disclosed at page 8, line 6 to page 9, line 3 and page 13, line 10 to page 14, line 2 of the application as filed in the context of the illustrative embodiments of the encoders

and decoder of the invention shown in figures 3, 4 and 5.

- 2.2 The description has been adapted to the amended claims and to mention the prior art known from D1 and D4.

Independent claims 1, 7, 11, 15 and 17 - Inventive step

3. The novelty of the subject-matter of the original independent claims has not been disputed.
4. None of the prior art documents D1 to D4 discloses a method of encoding an audio signal to generate an encoded signal, in which the encoding is based on a perceptual model and on a prediction of one of the spectral component signals of the audio signal which is based on one or more other ones of said spectral component signals, **the prediction being performed across the frequency domain**, as recited in claim 1. The method according to claim 1 thus is considered to be novel (Article 54(1) EPC). This prediction across the frequency domain, using a convolution of the applied spectral coefficients for each transformed block of the audio signal, results in a noise shaping in the time domain (published application: column 4, lines 8 to 14 and lines 30 to 33; column 8, lines 18 to 32). More specifically:
- 4.1 Document D4, which is concerned with frequency domain techniques for speech coding and discloses sub-band coders and transform coders, may be seen as the closest prior art. According to D4, "different frequency bands can be preferentially encoded according to perceptual criteria for each band, and quantizing noise can be

contained within bands and prevented from creating harmonic distortions outside the band" (page 512, right column, lines 5 to 13). In sub-band coding (figures 4, 5 and 6), each sub-band signal is coded by an APCM or ADPCM coder in which the quantizer step sizes are varied independently in each sub-band, and the shape of the quantising noise in frequency can be controlled in each sub-band (page 516, left column, lines 6 to 11; page 518, left column, lines 19 to 23 and right column, lines 2 to 8). In adaptive transform coding, "the transform coefficients, or frequency components, are then adaptively quantized and transmitted to the receiver (as in sub-band coding)" (page 519, left column, lines 17 to 23), a prediction signal ($\sigma_{SR}(k)$) representative of an estimate of one of the spectral coefficients is generated based on other ones of the spectral coefficients for the same spectral component (page 525, right column, line 12 to page 526, left column, line 22; equation (52)) and the choice of the bit allocation controls the distribution of the quantizing noise in the frequency domain (page 522, right column, last four lines). Accordingly, there is no disclosure in D4 of a prediction which is performed across the frequency domain and of a reconstructed signal which comprises temporally shaped coding noise.

- 4.2 D1 discloses "Temporal Waveform Coding" methods and more specifically the use of Differential Pulse Code Modulation (DPCM and Adaptive DPCM) in the time domain (pages 127 to 133; figures 3.5.3 and 3.5.6). D2, which relates to Speech Coding, describes an adaptive coder, such as ADPCM, for encoding each sub-band signal (pages 190 and 191; figure 3.3). Neither D1 nor D2 goes beyond the disclosure of D4. D3 merely relates to Image

- Compression Systems which comprise a DPCM encoder for coding the image samples in space. There is no disclosure of a prediction performed across the frequency domain in the patent documents acknowledged in the description of the originally filed application.
5. Starting from D4 and having regard to the effects provided by the claimed invention, the objective technical problem addressed by the invention can be seen as providing signal quality when coding transient signals such as, for example, castanet or glockenspiel sounds, in other words solving the known "pre-echo" problem, as recited in the originally filed application (published application, column 2, lines 17 to 20).

 6. This problem is solved by performing a prediction encoding across the frequency domain of one of the spectral component signals of the audio signal, as recited in claim 1. No disclosure, or suggestion, of such a solution can be found in the cited prior art documents, taken alone or in combination, because none of them discloses the generation of a prediction signal, which is performed across the frequency domain. It might be true that, when a time domain signal is spiky or transient, some correlation of spectral component signals could be observed in the frequency domain, as argued in the decision under appeal (page 4). However, this would not make it obvious to the skilled person aware of the use of ADPCM modulation techniques for sub-band speech coding that a prediction across the frequency domain would solve the "pre-echo" problem.

- 6.1 The foregoing considerations apply to independent claim 11, whose subject-matter is also distinguished over the cited prior art by the features "said prediction based on one or more others ones of said spectral component signals, the prediction being performed across the frequency domain" and independent claims 7 and 15, whose subject-matter is distinguished over the cited prior art by the feature b) recited in these claims, which specifies a prediction performed across the frequency domain.
- 6.2 As for claim 17, the recorded encoded audio signal has a data structure defined in terms which inherently comprise the technical features of the method according to claim 1 or the encoder according to claim 11, and is thus not a presentation of information as such, as explained in the decision T 1194/97 (OJ 2000, 525), see in particular point 3.3 of the reasons.
7. For the foregoing reasons, in the Board's judgement, the subject-matter of independent claims 1, 7, 11, 15 and 17 according to the current request is considered to be new and involve an inventive step within the meaning of Articles 54 and 56 EPC. The application as amended meets the requirements of the EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to grant a patent in the following version:

claims: 1 to 24 filed in the oral proceedings,

description: pages 1 to 3 and 5 to 14 as originally filed and pages 4 and 4A filed with letter of 17 March 2006,

drawings: figures 1 to 7 as originally filed.

The Registrar:

The Chairman:

U. Bultmann

W. J. L. Wheeler