음성인식 및 합성기술의 현황과 전망

오영환

한국과학기술원

전산학과

차례

음성

- 사람이 발성한 의미를 지니는 시계열 신호 (voice/speech)

- 가장 자연스러운 정보 교환 수단

- 음성 정보

  1) 언어 정보

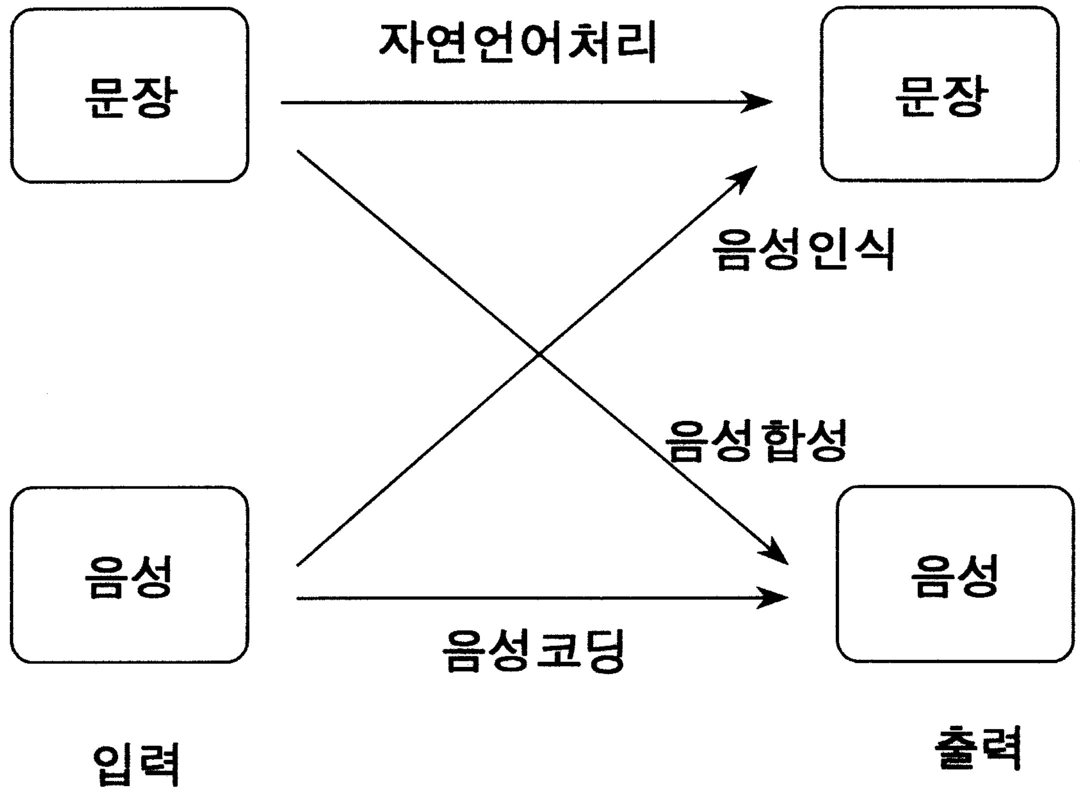
  2) 화자 정보

     개인, 성별, 연령층, 지역성, 사회계층, 성격 ....

  3) 상황 정보

     감정, 심리상태, 건강상태, 환경 ...

음성 통신의 형태



음성 인식의 장점

1) Natural

정보교환을 위한 별도의 교육이 필요 없다.

2) Flexible

사용이 편하고 눈과 손이 자유롭다.

3) Efficient

typing이나 손으로 쓰는 것보다 빠르다.

4) Economical

별도의 도구가 필요 없으므로 경제적이다.

5) 원격지

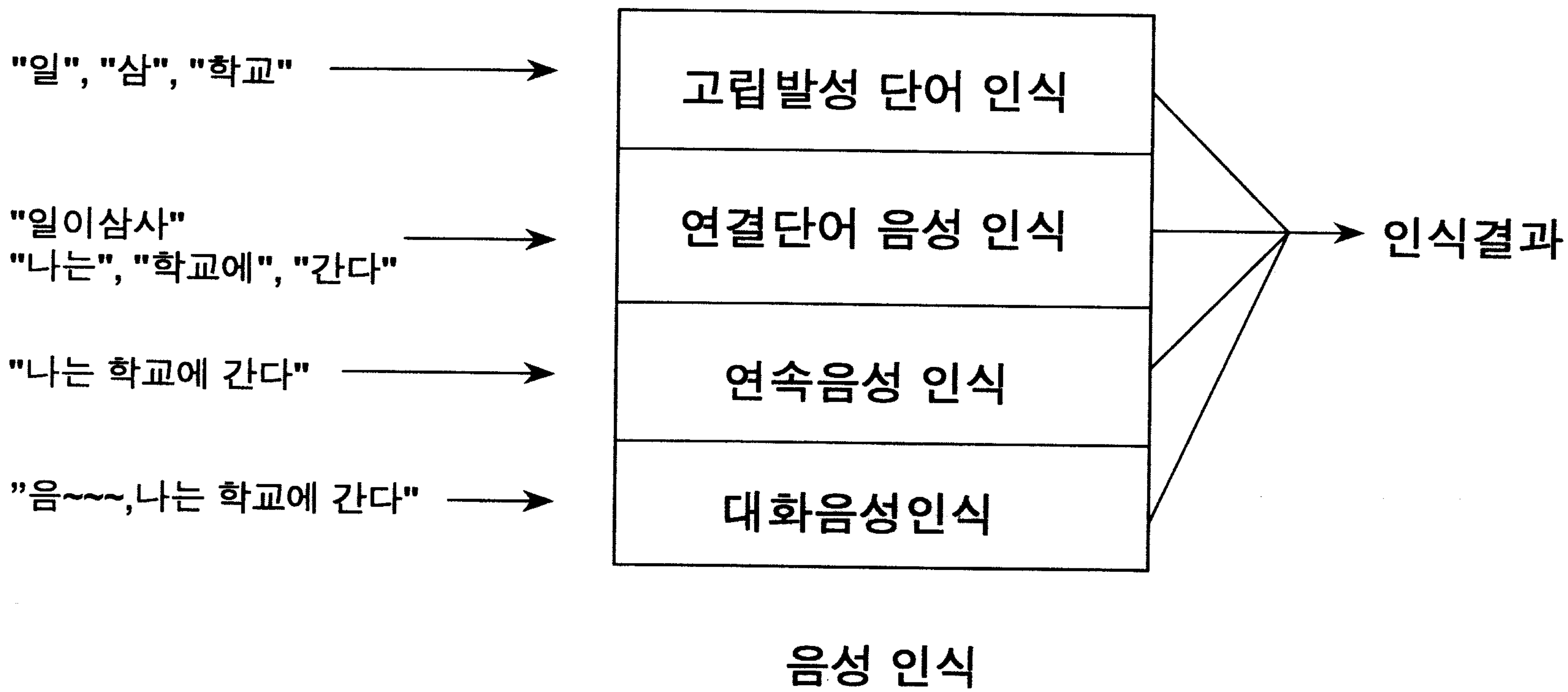
전화음성

6) 화자인식도 동시에 가능

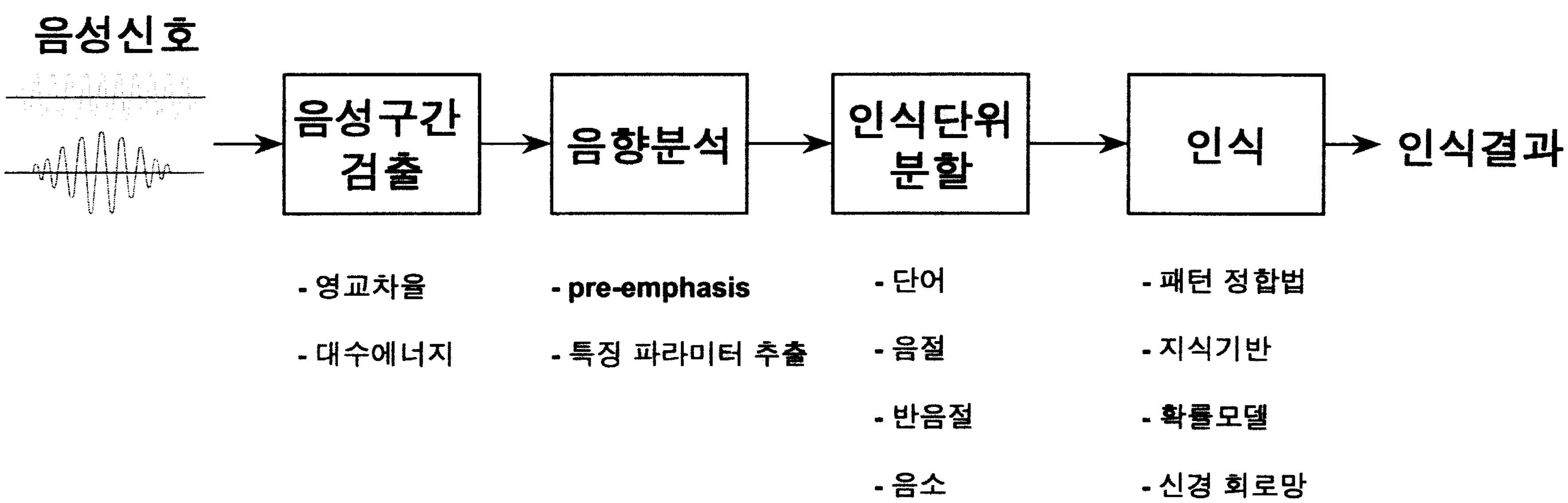
음성인식의 기술적 요인

발성방법	화자	어휘 수	음질
구분발성 <u>연속발성</u>	특정화자 <u>불특정화자</u>	소규모어휘 10 - 300 중규모어휘 100 - 2,000 <u>대규모어휘</u> 1,000 - 10,000 무제한	무소음 <u>저소음</u> 고소음

음성인식의 분류


"일", "삼", "학교"
"일이삼사"
"나는", "학교에", "간다"
"나는 학교에 간다"
"음~~~,나는 학교에 간다"
고립발성 단어 인식
연결단어 음성 인식
연속음성 인식
대화음성인식
인식결과
음성 인식

음성인식 과정



음성신호
음성구간 검출
음향분석
인식단위 분할
인식
인식결과
- 영교차율
- 대수에너지
- pre-emphasis
- 특징 파라미터 추출
- 단어
- 음절
- 반음절
- 음소
- 패턴 정합법
- 지식기반
- 확률모델
- 신경 회로망

음성인식 방법

- 인식모델을 이용한 음성인식
  - 동적정합법 (dynamic time warping)
  - HMM (hidden Markov model)
  - ANN (artificial neural network)
  - 전문가의 지식을 이용한 지식공학적 방법
- 언어모델을 이용한 탐색
  - word-pair, bigram, trigram 등
- 인식된 문장에 대한 구문분석
  - CFG(context free grammar), Chart parser 등을 이용
- 음성인식시 상위 N개의 후보를 대상으로 처리

음성 인식의 응용 분야

- command-and-control
- data entry
- data access
- dictation
- telephone use

음성 인식의 응용

◆ 응용분야

- Touch-tone 대용
- 예약 시스템(항공기,열차,호텔...)
- 안내 시스템(항공여행,소포추적,식당,전화번호,주가,철도)
- 공중망을 이용한 문헌 및 정보 검색 시스템(DDD 안내 : 도시명)
- 신체 장애자용 기기
- Voice control system (remote input)

음성인식 시스템 현황

개발자	국명	시스템명	특 징	단어수	인식율(%)
CMU	미국	SPHINX	화자독립 연속음성	1,000	96.4
SRI	미국	DECIPHER	화자독립 연속음성	1,000	95.2
BBN	미국	BYBLOS	화자종속 연속음성 화자적응	1,000	98.7 94.8
Lincln Lab.	미국		화자독립 연속음성	1,000	87.4
ATR	일본		화자종속 연속음성 화자적응	1,035	95.3 89.7
KAIST	한국		화자독립 연속음성	3,064	96.7
IBM	미국	Tangora	화자종속 고립단어	20,000	95.0
NEC	일본		화자종속 고립단어	1,800	97.5

화자 인식

- 음성 = 화자정보 + 언어정보 + 상황정보

  성문 (voice print) : sonagraph / spectrograph

- 음성의 개인 특성

1) 선천적 요인 ; 성대, 성도의 차이

   - 주파수 구조상의 차이

2) 후천적 요인 : 억양, 강세, 빠르기

   - 주파수 구조의 시간적 변화

화자인식의 분류

- 인식형태에 의한 분류
  - 화자 식별 (speaker identification) : 범죄수사
  - 화자 확인 (speaker verification) : 출입관리 등 본인확인

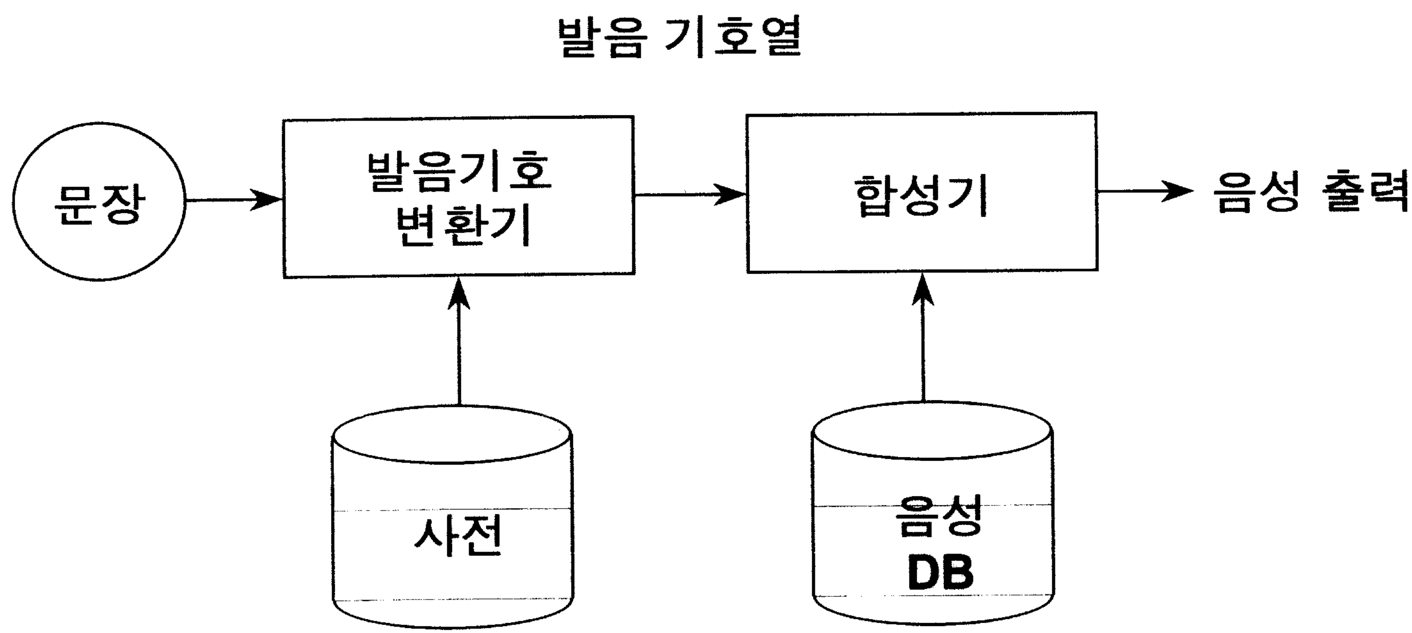
- 문장의 의존성 여부
  - 문장 고정형 (text dependent) : 특정 단어
  - 문장 자유형 (text independent) : 자연스러운 발성

화자 인식

- 응용분야
  - 개인 정보 / 기밀 정보 검색 (network access control)
  - 기밀지역 / 건물 출입통제
  - **home banking / phone banking**

음성 합성

- 입력된 문장을 음성으로 변환 (분석의 역방향)



음성 합성

1) 녹음 편집형

- 음성신호(96 kbit/sec) -> 12 - 24 kbit/sec ADPCM
- 어휘수 제한, 음질 우수
- ARS 등에 이용

2) 분석 합성형

- 파라미터의 편집
- LPC, cepstrum
- 음질 양호
- 1.2 - 9.6 Kbit/sec

음성 합성

3) 소편 편집형

- 조음 결합, 운율정보 처리 미흡
- 100 - 2000개 정도의 합성단위가 필요
- 실용화를 위해서는 많은 연구가 필요

4) 규칙 합성형

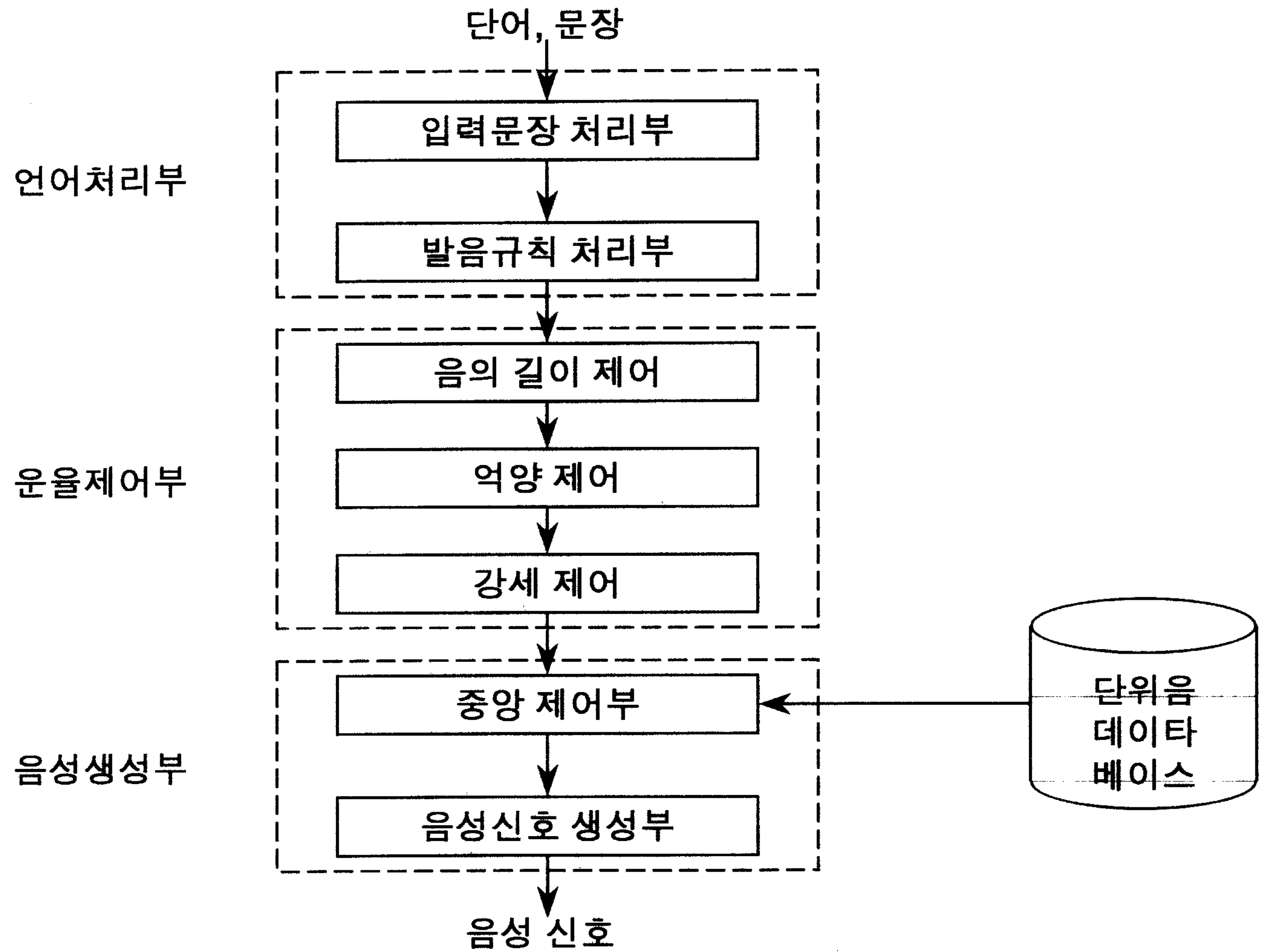
- 음성 생성모델 이용
- 조음결합, 운율패턴 등을 규칙화
- 음질의 개선여지 남아있음

문서-음성 변환 시스템 (Text-to-Speech System)

- 임의의 문장을 입력 받아 해당하는 음성신호로 변환하는 장치

- 문서-음성 변환 시스템의 구성
  - 언어처리부 : 입력된 문장을 발음기호열로 변환
  - 운율제어부 : 합성음에 운율 정보 반영
  - 음성생성부 : 합성단위를 접속하여 음성합성

문서-음성시스템의 구성



한국과학기술원 전산학과

음성 합성

- 합성음의 음질
  - 명료성 **(intelligibility)**
  - 자연성 **(naturalness)**
- 합성음의 음질 개선
  - 억양, 강세, 길이, 휴지기 등의 운율 반영
  - 운율제어에 관한 규칙 필요
- 의미정보를 이용한 음성합성
  - 구문구조, 문형, 의미등을 쉽게 파악
  - 운율정보 생성이 용이
  - 예 : **CTS (concept-to-speech)**

    SOSC (speech output from case structure)

결론 및 전망

- 미래사회의 필수 기술
  - **21세기 영향력 있는 10대 기술 : 음성인식**
  - **VUI (Voice user interface)**
- 제한된 응용 분야의 실용화 단계
  - 수요 폭발 직전 단계
- 지속적인 대규모 연구 필요
  - 광범위한 연구집단에 의한 공동연구
  - 지속적인 국가차원의 연구지원 긴요

    (대규모 음성 **DB** 등)

A Flexible 2-Dimension Orthogonal Spreading Code Design for Multi-rate Parallel Transmission

Xiao, Lei Liang, Qinglin
(Department of Electronics, Peking University, Beijing 100871, P.R.China)

Abstract In this paper, we examine a flexible 2-Dimension orthogonal spreading code suitable for multi-rate parallel transmission. We first introduce the structure of this 2-Dimension orthogonal spreading code. Then we analyze the various orthogonal characteristics between different codes. Finally we provide a principle to allocate codes for various channels. Our results show that this kind of spreading code can avoid the degrading effect of some hostile conditions and keep the orthogonal characteristics of various channels supporting multi-rate to improve the performance of the whole system.

Key words parallel transmission, 2-Dimension orthogonal spreading code, multi-rate

I. Introduction

One primary character of the future communication system is that it can provide multiple kinds of services. Moreover, whether or not support multimedia service is viewed as one of important standards to evaluate various kinds of the recommendations for the Third Generation Mobile Communication System by the ITU[2]. Among these recommendations[3][4], variable rate services are often implemented through modulating processing gain or using multi-code transmission. In these schemes, the orthogonal characteristics of the spreading code is possible destroyed by some elements, such as multi-path fading, asynchronous transmission and so on. At this time the variable rate services will damage the system performance greatly. On the other hand, parallel transmission, such as multicarrier transmission [6][7], is especially in favor of high rate transmission. In this paper, we present a kind of 2-Dimension orthogonal spreading code designed for parallel transmission in order to improve the performance of the system by making the most use of the orthogonal characteristics between codes.

Firstly we introduce the structure and mathematical expression of this 2-Dimension orthogonal spreading code. Then we authenticate the orthogonal characteristics of this kind of spreading code. Finally we study the principle to allocate codes for various channels and rates.

II. The Structure of 2-Dimension orthogonal spreading code

As the OVSF codes introduced in W—CDMA recommendation for the Third Generation Mobile Communication[4][5], we can achieve the structure of the 2-Dimension orthogonal spreading code. These codes can be represented by matrix, in which each line represents one dimension of spreading code, which can be called X field spreading code, and each column represents the other dimension of spreading code, which can be called Y field spreading code. One of inborn structure is shown in Figure 1, where the transversal expansion stands for the X field evolvement, and the vertical expansion stands for the Y field evolvement.

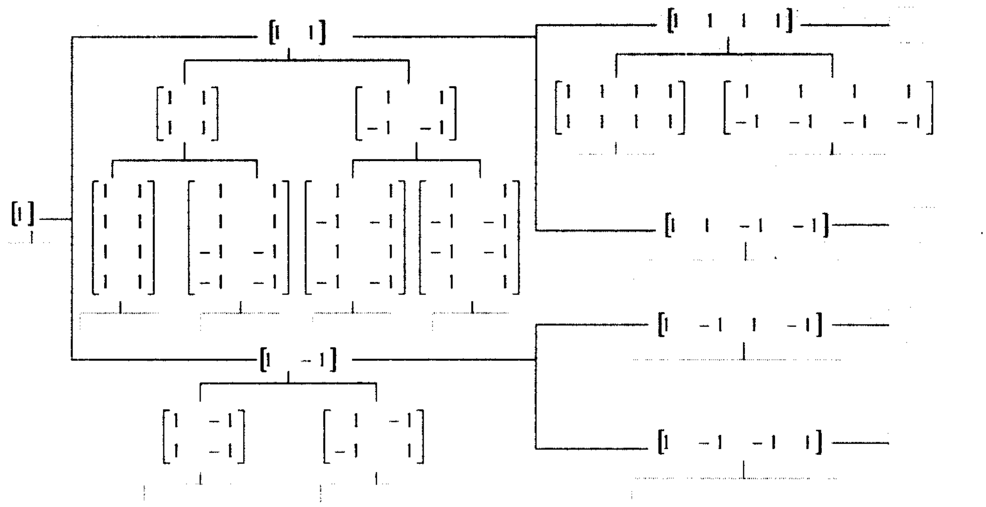


Figure 1. Inborn Structure of 2-Dimension spreading code focused on orthogonal characteristics in the X field

In Figure 1, any codes can be expressed mathematically as $\mathbf{H}_{m\ n}^{i\ j}$:

- m: the number of lines, i.e. code length in the Y field, must be equal to the power of 2;
- n: the number of columns, i.e. code length in the X field, must be equal to the power of 2;
- i: the serial number in the Y field, less than m.
- j: the serial number in the X field, less than n.

So, the recursive relation is

$$\mathbf{H}_{1\ 1}^{0\ 0} = [1];\ \text{X field expansion means } \mathbf{H}_{m\ n}^{i\ j} = \begin{bmatrix} \mathbf{H}_{m\ \ n/2}^{i\ \ j \bmod n/2} & p \cdot \mathbf{H}_{m\ \ n/2}^{i\ \ j \bmod n/2} \end{bmatrix};$$

$$\text{Y field expansion means } \mathbf{H}_{m\ n}^{i\ j} = \begin{bmatrix} \mathbf{H}_{m/2\ \ n}^{i \bmod m/2\ \ j} \\ q \cdot \mathbf{H}_{m/2\ \ n}^{i \bmod m/2\ \ j} \end{bmatrix}$$

$$p = \begin{cases} 1 & j = 0 \cdots n/2 - 1 \\ -1 & j = n/2 \cdots n-1 \end{cases}$$

$$q = \begin{cases} 1 & i = 0 \cdots m/2 - 1 \\ -1 & i = m/2 \cdots m-1 \end{cases}$$

In Figure 1, $\mathbf{H}_{1\ n}^{0\ j}$ are the unique codes that can expand not only transversally but also vertically, which can be called ancestor. Other non-ancestor codes can only expand vertically for avoiding the existence of the same codes. According to the opposite ways, we can achieve another inborn structure of 2-Dimension spreading code as shown in Figure 2. In Figure 2, $\mathbf{H}_{m\ 1}^{i\ 0}$ are the unique codes that can expand not only transversally but also vertically, which can be called ancestor, and other non-ancestor codes can only expand transversally. The two figures are equivalent, but they have different use in the argument about X field or Y field distinctly. For example, in the two figures, the codes derived from the transversal expansion of ancestor can be called X field descendants, and the codes derived from the vertical expansion of ancestor can be called Y field descendants. However, in figure 1, the Y field ancestor of code $\mathbf{H}_{m\ n}^{i\ j}$ is unique, that is $\mathbf{H}_{1\ n}^{0\ j}$; in figure 2, the X field ancestor of code $\mathbf{H}_{m\ n}^{i\ j}$ is unique, that is $\mathbf{H}_{m\ 1}^{i\ 0}$.

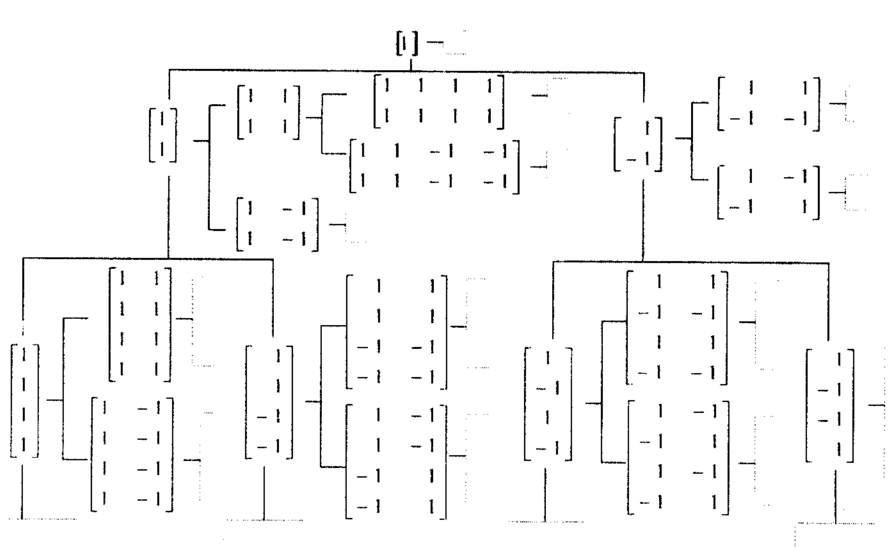


Figure 2. Inborn Structure of 2-Dimension spreading code focused on orthogonal characteristics in the Y field

As shown in figure 1 or figure 2, there are $m*n$ different codes if m and n are fixed. From another point of view, for $\mathbf{H}_{m\ n}^{i\ j}$, i ranges from 0 to m-1 and j ranges from 0 to n-1, so there are $m*n$ different codes considering different combination of i and j. These codes are orthogonal in X field or in Y field or in both fields. However, it is not the most outstanding advantage for the 2-Dimension spreading code. If two codes have different value of m or different value of n, they can also be orthogonal in the sense of interception. So, two signals with different data rate can be orthogonal if they are spreaded by two different 2-Dimension orthogonal spreading codes. The following is the authentication of this special orthogonal characteristic.

III. Orthogonal Characteristics Authentication

*Lemma 1:*For any code $\mathbf{H}_{m\ n}^{i\ j}$, its every line vector is a positive or negative Walsh vector which period is n and serial number is j, and its every column vector is a positive or negative Walsh vector which period is m and serial number is i.

Proof: From the reference[1], the Walsh vector which period is k and serial number is l can be expressed recursively as

$$\mathbf{W}_k^l = \left[\mathbf{W}_{k/2}^{l \bmod k/2} \quad z \cdot \mathbf{W}_{k/2}^{l \bmod k/2}\right],\ z = \begin{cases} 1 & l = 0 \cdots k/2-1 \\ -1 & l = k/2 \cdots k-1 \end{cases},\ \mathbf{W}_1^0 = 1.$$

From the comparison between this expression and the X field and the Y field expansive equations of the 2-Dimension spreading code, the *Lemma 1* is true.

Definition 1: Define the element that lies in the k^{th} line and l^{th} column of code $\mathbf{H}_{m\ n}^{i\ j}$ as $h_{m\ n}^{i\ j}(k,l)$.

Definition 2: Define the k^{th} line vector of code $\mathbf{H}_{m\ n}^{i\ j}$ as $\mathbf{L}_{m\ n}^{i\ j}(k)$.

Definition 3: Define the u^{th} intercept of $\mathbf{L}_{m\ n\cdot 2^p}^{i\ j}(k)$, the k^{th} line vector of code $\mathbf{H}_{m\ n\cdot 2^p}^{i\ j}$, according to the interval n as $\left[\mathbf{L}_{m\ n\cdot 2^p}^{i\ j}(k)\right]_u$.

Definition 4: Define the l^{th} column vector of code $\mathbf{H}_{m\ n}^{i\ j}$ as $\mathbf{W}_{m\ n}^{i\ j}(l)$.

Definition 5: Define the u^{th} intercept of $\mathbf{W}_{m\cdot 2^p\ n}^{i\ \ j}(l)$, the l^{th} column vector of code $\mathbf{H}_{m\cdot 2^p\ n}^{i\ \ j}$, according to the interval m as $\left[\mathbf{W}_{m\cdot 2^p\ n}^{i\ \ j}(l)\right]_u$.

1. The Orthogonal Characteristics in the X Field

Proposition 1: The crosscorrelation between $\mathbf{L}_{m\ n}^{i\ j}(k)$, the k^{th} line vector of code $\mathbf{H}_{m\ n}^{i\ j}$, and $\mathbf{L}_{m'\ n}^{i'\ j'}(k')$, the k'^{th} line vector of code $\mathbf{H}_{m'\ n}^{i'\ j'}$ is

$$\mathbf{L}_{m\ n}^{i\ j}(k)\bullet[\mathbf{L}_{m'\ n}^{i'\ j'}(k')]^T=\sum_{l=1}^{n}h_{m\ n}^{i\ j}(k,l)\cdot h_{m'\ n}^{i'\ j'}(k',l)=\begin{cases}\pm n & j=j'\\ 0 & j\neq j'\end{cases}.$$

Proof: According to the *Lemma 1*, $\mathbf{L}_{m\ n}^{i\ j}(k)$ is a positive or negative Walsh vector which period is n and serial number is j, and $\mathbf{L}_{m'\ n}^{i'\ j'}(k')$ is a positive or negative Walsh vector which period is n and serial number is j'. According to the orthogonal characteristics of Walsh function, the *Proposition 1* is true.

Proposition 1 shows the orthogonal characteristics between the line vectors of two codes with the same number of columns, i.e. the same X field expansion: if two codes have different serial number in the X field ($j\neq j'$), their line vectors is orthogonal.

Proposition 2: $\left[\mathbf{L}_{m\ n\cdot 2^p}^{i\ \ j}(k)\right]_u=\pm\mathbf{L}_{m\ \ n}^{i\ \ j \bmod n}(k)$.

Proof: According to the X field recursive relation of code $\mathbf{H}_{m\ n\cdot 2^p}^{i\ \ j}$, the *Proposition 2* is true.

Proposition 3: The crosscorrelation between $\mathbf{L}_{m\ n}^{i\ j}(k)$ and $\left[\mathbf{L}_{m'\ n\cdot 2^p}^{i'\ \ j'}(k')\right]_u$, the u^{th} intercept of $\mathbf{L}_{m'\ n\cdot 2^p}^{i'\ \ j'}(k')$, is

$$\mathbf{L}_{m\ n}^{i\ j}(k)\bullet[\mathbf{L}_{m'\ n\cdot 2^p}^{i'\ \ j'}(k')]_u^T=\pm\sum_{l=1}^{n}h_{m\ n}^{i\ j}(k,l)\cdot h_{m'\ \ n}^{i'\ \ j' \bmod n}(k',l)=\begin{cases}\pm n & j=j' \bmod n\\ 0 & j\neq j' \bmod n\end{cases}$$

Proof: According to the *Proposition 1* and *Proposition 2*, the *Proposition 3* is true.

Proposition 3 shows the orthogonal characteristics between the line vectors of two codes with different number of columns, i.e. different X field expansion: if two codes have different serial number in the X field ($j\neq j' \bmod n$), where the serial number of the code with more columns must be moduled by the X field length of the code with less columns, their line vectors is orthogonal.

According to Figure 1 and the recursive relation of 2-Dimension spreading code, the propositions above can be expressed more graphically. In one word, the *Proposition 1* and *Proposition 3* enunciate the orthogonal characteristics in the X field: for any two codes in the figure 1, if their Y field ancestors have not derivative relation in the X field, their line vectors is orthogonal.

2. The Orthogonal Characteristics in the Y Field

Proposition 4: The crosscorrelation between $\mathbf{W}_{m\ n}^{i\ j}(l)$, the l^{th} column vector of code $\mathbf{H}_{m\ n}^{i\ j}$, and $\mathbf{W}_{m\ n}^{i'\ j'}(l')$, the l'^{th} column vector of code $\mathbf{H}_{m\ n}^{i'\ j'}$ is

$$\mathbf{W}_{m\ n}^{i\ j}(l)\bullet[\mathbf{W}_{m\ n}^{i'\ j'}(l')]^T = \begin{cases} m & i = i' \\ 0 & i \neq i' \end{cases}$$

Proposition 5: $\left[\mathbf{W}_{m\cdot 2^p\ n}^{i\ \ j}(l)\right]_u = \pm\mathbf{W}_{m\ \ \ \ n}^{i \bmod m\ j}(l)$

Proposition 6: The crosscorrelation between $\mathbf{W}_{m\ n}^{i\ j}(l)$ and $\left[\mathbf{W}_{m\cdot 2^p\ n}^{i'\ \ j'}(l')\right]_u$, the u^{th} intercept of $\mathbf{W}_{m\cdot 2^p\ n}^{i'\ \ j'}(l')$, is

$$\mathbf{W}_{m\ n}^{i\ j}(l)\bullet[\mathbf{W}_{m\cdot 2^p\ n}^{i'\ \ j'}(l')]_u^T = \pm\sum_{k=1}^{m} h_{m\ n}^{i\ j}(k,l)\cdot h_{m\ \ \ \ n}^{i' \bmod m\ j'}(k,l') = \begin{cases} \pm m & i = i' \bmod m \\ 0 & i \neq i' \bmod m \end{cases}$$

The proofs of the *Proposition 4, Proposition 5* and *Proposition 6* are similar to the proofs of the *Proposition 1, Proposition 2* and *Proposition 3.*

Similarly, according to Figure 2 and the recursive relation of 2-Dimension spreading code, the propositions above can be expressed more graphically. In one word, the *Proposition 4* and *Proposition 6* enunciate the orthogonal characteristics in the Y field: for any two codes in the figure 2, if their X field ancestors have not derivative relation in the Y field, their column vectors is orthogonal.

IV. The Principle for Codes Allocation

In the realistic system, various elements, such as channel fading, asynchronous transmission and so on, may affect the 2-Dimension orthogonal characteristics of the codes. However, as long as the orthogonal characteristics can be satisfied in any field, the performance will be improved greatly. So before selecting codes, we must judge the orthogonal condition in the X field and Y field according to the system status. On this condition, we achieve following principle for code allocation according the propositions above.

1. Orthogonal in the X Field, but not in the Y Field

(1)Sort all the channels by their highest rate supported in descending order.

(2)Supposing the channel u is the first channel in the list. According to its highest rate and performance requirement, allocate one code, such as $\mathbf{H}_{m\ n}^{i\ j}$, with minimal Y field expansion in the Figure 1.

(3)Set all the Y field ancestors in the course from the root, $[1]$, to $\mathbf{H}_{m\ n}^{i\ j}$ and their Y field descendants as "used".

(4)Set all the X field and Y field descendants of the Y field ancestor of $\mathbf{H}_{m\ n}^{i\ j}$ as "used" and mark them as u.

(5)Delete channel u from the list.

(6)Repeat the process (2) to (5) until all the channels have been allocated a code.

(7)When the data rate changes in the channel v, select one code from those marked as v and matched with the rate requirement.

According to the principle, other channels will not be affected by the rate variation of any channel. If the data rates in all the channels are same and all the spreading codes have the same value of m and n according to the requirement of system, there are n different orthogonal codes in this case. That is, n orthogonal users can be supported.

2. Orthogonal in the Y Field, but not in the X Field

The principle is the same as that of 1, but the inborn structure of 2-Dimension spreading code should adopt Figure 2 and exchange between Y field and X field should be made in the principle above.

In this case, if m and n are fixed, there are m different orthogonal codes. That is, m orthogonal users can be supported.

3. Orthogonal in the both X Field and Y Field

(1)Sort all the channels by their highest rate supported in descending order.

(2)Supposing the channel u is the first channel in the list. According to its highest rate and performance requirement, allocate one code, such as $\mathbf{H}_{m}^{i}{}_{n}^{j}$.

(3)Set all the joints in the course from the root to $\mathbf{H}_{m}^{i}{}_{n}^{j}$ as "used" in both Figure 1 and Figure 2.

(4)Find all the joints in the course from $\mathbf{H}_{m}^{i}{}_{n}^{j}$ to its Y field ancestor in Figure 1. In Figure 2, set all the X field descendants of these joints and all those joints in the course from the root to them as "used".

(5)Find all the joints in the course from $\mathbf{H}_{m}^{i}{}_{n}^{j}$ to its X field ancestor in Figure 2. In Figure 1, set all the Y field descendants of these joints and all those joints in the course from the root to them as "used".

(6)Set all the Y field descendants of $\mathbf{H}_{m}^{i}{}_{n}^{j}$ in figure 1 and X field descendants of $\mathbf{H}_{m}^{i}{}_{n}^{j}$ in Figure 2 as "used" and mark them as u.

(7)Delete channel u from the list.

(8)Repeat the process (2) to (7) until all the channels have been allocated a code.

(9)When the data rate changes in the channel v, select one code from those marked as v in Figure 1 or Figure 2 and matched with the rate requirement.

According to the principle, other channels will not be affected by the rate variation of any channel.

In this case, if m and n are fixed, there are $m*n$ different orthogonal codes. That is, $m*n$ orthogonal users can be supported.

It is obvious that the principle to allocate 2-Dimension spreading code is more complex than that for 1-Dimension spreading code[1]. However, it is more flexible to support multi-rate service and more suitable to realistic hostile communication condition and so provides better performance.

V. Application Example

If we view X field as time field and Y field as frequency field, one application of the proposed 2-Dimension orthogonal spreading code lies in the multicarrier-CDMA system. In this system, the orthogonal characteristics in the time field can be maintained by the design of narrow band carrier, but the orthogonal characteristics in the frequency field will be destroyed partially due to frequency selective fading. So if we apply the 2-Dimension orthogonal spreading code for this system, the orthogonal spreading codes in the time field, the line vector of 2-Dimension orthogonal spreading code, can provide excellent multi-access capability, and the spreading codes in the frequency field, the column vector of 2-Dimension orthogonal spreading code, can provide frequency diversity and some multi-access capability. For this system, if m and n are fixed, $m*n$ users can be supported at most. Among them, every n users are orthogonal, so the multiuser interference is decreased n times. For example, if m=4 and n=16, totally 64 users can be supported. For the conventional single carrier DS-CDMA system, totally 63 users will generate interference to one user with spreading ratio 64. However, for the multicarrier system applying the 2-Dimension orthogonal spreading code, only 3 users will generate interference to one user with spreading ratio 4 in the frequency field. On the other hand, when the data rate are varied, the DS-CDMA system will suffer great performance deterioration, but the multicarrier system applying the 2-Dimension orthogonal spreading code can modulate its spreading codes according to the principle above, so the performance will not be affected greatly due to the maintained orthogonal characteristics.

Another application lies in the asynchronous transmission such as the reverse link in mobile communication. In this case, the orthogonal characteristics in the time field will be destroyed due to the asynchronous signal. If parallel transmission is adopted and the 2-Dimension orthogonal spreading code is applied, the performance will be improved. In this case, different parallel branches for one user's signal adopt different line vectors of 2-Dimension orthogonal spreading code, and different users' signals apply different column vectors. Firstly, the signals belonging to the user itself are orthogonal in the time field because they are synchronous, so the orthogonal spreading codes in the time field, the line vectors of 2-Dimension orthogonal spreading code, can distinguish them perfectly. Then the signals belonging to different users can also be distinguished perfectly by the orthogonal column vectors that are transmitted at the same time. Moreover, the advantage of supporting variable-rate services is also outstanding.

VI. Conclusion

In this paper, we examine a flexible 2-Dimension orthogonal spreading code suitable for the parallel transmission. Moreover, we authenticate the orthogonal characteristics of the 2-Dimension spreading code and provide a scheme to support variable-rate services. Through the design of this kind of spreading code, we can avoid the degrading effect of some hostile conditions and keep the orthogonal characteristics of various multi-rate supporting channels to improve the performance of the whole system.

The combination between the designing method of the 2-Dimension orthogonal spreading code and realistic parallel transmission methods, such as multicarrier transmission, OFDM and so on, still needs further study.

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