ABSTRACT
This paper describes a music visualization method called Misual. The goal of this research is to provide objective and static information regarding musical impressions that will enable people to efficiently categorize a large number of music pieces and select favorites from them. Features are directly extracted from music and then visualized in an image that suits human intuition. As a first step in this research, volume transitions and repetitions are focused as the visualized objects. For the volume transition, power information is extracted and then smoothed by a moving average. This information is continuously visualized with 3D-like images, in which radii of circles reflect the volume information. Repetitions are visualized with color. These are detected on the basis of the frame-to-frame similarity measured by the Mel-frequency cepstrum. These two kinds of information were visualized for three pieces of real music. The visualizations will be useful for roughly grasping the musical features in a very short time and imagining the music intuitively.

Categories and Subject Descriptors
H.5.5 [Information Interfaces and presentation]: Sound and Music Computing

Keywords
music, visualization

1. INTRODUCTION
A tremendous number of music pieces are generated every day all over the world, making it very difficult to find desired ones among them. Although other people's remarks might sometimes be useful for the search, such remarks are not reliable enough, because they are generated through dual filters, "other people" and "verbalization". In the end, this means we would have to listen to each piece to decide whether or not it for us. This would be very time consuming. In addition, our impression of a piece fades as we listen to it, and it is hard for us to recall our impression because music is a transient media. The fact that we need a lot of time to listen to pieces however we can hardly obtain their tough-to-fudge impression seem to make it difficult to organize the pieces we already have and to find desired new ones. Objective and static information regarding music impressions is necessary in order to efficiently organize and find music pieces in this music-explosion era.

The ultimate goal of this Misual research, music visualization, is the visualization of the physical quantities of musical elements that affect impressions in images/colors/shapes, which can be understood intuitively. Visualizing music means the translation from transient media to permanent media. This makes it possible to recall one's impression of music, to compare pieces, and so on. Further, if images can be made to represent physical quantities of musical elements that can be grasped intuitively, people will be able to imagine how the music sounds before listening to it. Such music images could be used in new styles of new music education. For example, students will be able to learn changes in the length and complexity of music by looking at musical images ordered in time.

This paper proposes a music image that represents volume transition and repetition in a piece of music as the first step towards music visualization. This is not enough to achieve efficient music categorization and selection. However, volume transition implies whether a piece of music has vocals or not in a certain extent. Information regarding repetition in a piece of music is important since it is related to affinity for the music, though of course the relationship between repetition and affinity varies from person to person.

This paper is organized as follows. Section 2 covers related work. Section 3 describes features extracted from music and techniques for processing them to make music images. Target pieces of music are analyzed in Section 4. Section 5 presents experimental results on these targets. Future work is discussed in Section 6. Section 7 summarizes the paper.

2. RELATED WORK
There are two motivations behind music visualization research: visualization of music itself [12, 22] and visualization as a tool to show research results on paper [3, 4, 5, 10, 11]. Regarding the second motivation, researchers have made "music thumbnails" and "audio summarization" by detecting the most representative part of a piece of music. The most representative part in a piece has been defined as the most frequently repeated component in it. In particular, methods have been proposed to detect such components
and display them in images as a means to show the effectiveness of certain research proposals and results. Regarding the first motivation, the focus has been to help people to understand music by displaying music structures in an easy-to-understand way. Although the individual studies on this topic have had their individual focus, the importance of knowing the musical structure has been widely cited [2, 14, 22].

Music structure analysis is a very difficult research topic. At present, no complete theory for it exists. However, there is encouraging research on detecting the most frequently appearing component in a piece of music based on music structure analysis. In particular, PCM acoustic data has been used. Some researchers have found repetitions by performing self-similarity calculations with Mel-Frequency Cepstrum Coefficients [3, 4, 10], whereas others have identified them based on approximate transcription results [5, 11].

Music visualization has been researched using MIDI data [12, 23]. MIDI data clearly indicates musical information about tracks, notes, volumes, and so on. The visualization results look like a colored music score. In one of the visualization methods, each track has its own axis in the time-wise sense and each note is expressed as a sphere. Pitch and volume are expressed in terms of the note's height and size. Thus, the resulting image lets people see what instrument is being played when and how loud it is. Although MIDI data is easy to handle, a serious problem is that MIDI data does not exist for many pieces of music.

Instead of using MIDI data, the author wants to find information, extractable directly from music, that, after appropriate processing, might be helpful for people to imagine and understand music. The information I seek is mainly of the sort discussed in acoustic psychology [17, 21] and as such, its significance is an on-going research topic. Accordingly, this research should be based on the research results of acoustic psychology and at the same time, this research should contribute to acoustic psychology research. The musical information that I create and visualize will be able to help people to intuitively understand the music’s features in a very short time.

3. APPROACHES

This paper focuses on volume transitions and parts that are performed repetitively. PCM data in WAV format is used as the acoustic data. The data is processed with an FFT (Fast Fourier Transform). The unit of FFT processing is called a “frame”.

3.1 Volume Transition

I represent the volume transition with the power information smoothed by a moving average.

The volume data at the frame number \( t \) is represented as \( v(t) \). For a better view, the transitions could be smoothed by a moving average. A filter that emphasizes the power data of neighbors nearer to the central data, \( v(t) \), is used for the moving average processing

\[
\tau(t) = \frac{1}{W} \sum_{i=0}^{4} w_i v(t+i), \quad W = \sum_{i=-2}^{3} w_i
\]

where \( w_i \) is called the weight coefficients. Here, I used Savitzky-Golay weight coefficients. The coefficients are presented in

\[
w_i = \frac{3}{(3k^2 - 1)(2k + 3)} \left( 3k^3 + 3k^2 + 3k + 1 \right)
\]

where \( k \) \((-k \leq i \leq k)\) is the number of neighbors used for smoothing.

The volume transition is presented in a 3D-like image by continuously drawn circles whose radii are \( \tau(t) \) at time \( t \). This image is called the base image.

3.2 Repetition Identification

Parts that are repetitively performed are detected and visualized. Each set of repetitions is allocated a single color in the visualization.

3.2.1 Extracting and Processing

MFCC (Mel-Frequency Cepstrum Coefficient) is used as a feature of acoustic data. The MFCC calculation uses filter banks based on \( L \) triangle windows in the frequency domain [7, 20]. The filter banks are used to calculate \( m(l) \), the weighted sum of the power spectrum \( |S[l]| \), where \( k \) is a frequency channel and \( W(k; l) \) is the weight.

\[
m(l) = \sum_{k=0}^{L-1} W(k; l) |S[l]| \quad (1 \leq l \leq L)
\]

\[
W(k; l) = \begin{cases} t_{k}(l) & k_{l}(l) \leq k \leq k_{l}(l) \\ t_{k}(l) & k_{l}(l) \leq k \leq k_{h}(l) \\ 0 & k_{h}(l) \leq k \leq L \end{cases}
\]

where \( k_{l}(l) \) and \( k_{h}(l) \) are the lowest, the center, and the highest number of frequency components for the \( L \)-th filter bank, respectively. They have a relationship as follows.

\[
k_{l}(l) = k_{h}(l - 1) = k_{l}(l + 1)
\]

The \( k(l) \)'s are ordered at even intervals on the Mel-frequency axis. The Mel-frequency of the frequency \( f \) (Hz) is calculated as follows.

\[
Me(f) = 2595 \log_{10} \left( 1 + \frac{f}{700} \right)
\]

The \( L \) power values are processed with a discrete cosine transform, and the MFCC vectors, \( V(k) \), are obtained as follows.

\[
V(k) = \sqrt{\frac{1}{N}} \sum_{l=1}^{L} \log m(l) \cos \left( l - \frac{1}{2} \frac{k \pi}{L} \right)
\]

**MFCC distance calculation.** The similarity of a pair of frames is measured using the distance calculated with the MFCC vectors. The vector of the \( i \)-th frame is represented by \( V(k) \). The distance between the \( i \)-the frame and the \( j \)-the frame, \( D(i, j) \), is calculated as follows.

\[
D(i, j) = \sqrt{\sum_{k=0}^{M-1} (V(k) - V_j(k))^2}
\]

where \( f_r \) is the number of frames in the piece of music and \( M \) is the dimension of the MFCC vector. Figure 1 plots small \( D(i, j) \)'s. The lower right part is omitted because it is a mirror image of the upper left.
calculate the diagonal series data $S(j)$.

$$S(j) = \sum_{i=0}^{j} \frac{D(i, i+j)}{j}, \quad 1 \leq j < \ell$$

If $S(j)$ is small, there might be a candidate pair, $P_j(r, l)$, in it. $P_j(r, l)$ represents a candidate pair of length $\ell$; one starts from frame number $r$ and the other starts from frame number $r + j$. The $i$ smallest $S(j)$’s are picked up as candidate series that may contain candidate pairs. From each $S(j)$, segments that contain series of frames whose MFCC distances are smaller than a threshold, $h_1$, for more than $h_2$ seconds are picked up as candidate pairs. When there are some frames whose MFCC distance is bigger than the threshold, if the length is less than $h_3$ seconds, the segment is permitted to be a candidate. The value of $h_1$ should not be too small, so that all candidate pairs are picked up without fail.

Next, the average distance, $\bar{D}_j(r, l)$, of a candidate pair, $P_j(r, l)$, is calculated as follows.

$$\bar{D}_j(r, l) = \sum_{i=0}^{j} \frac{D(i, i+j)}{l}$$

A pair whose average distance is bigger than a threshold, $h_4$, is omitted from the candidates.

Candidate pairs that seem to belong to the same repeat component are collected based on each pair’s relationship. For example, if A and B are a candidate pair and B and C also are, then A, B, and C are collected as those that belong to an identical repeat component. Candidate pairs are collected if their lengths are almost the same and the start frames of either counterpart of each pair are also almost the same. Regarding the candidate pairs $P_j(r_j, l_j)$ and $P_k(r_k, l_k)$, if $l_j \approx l_k$ and one of the following equations is satisfied, $P_j(r_j, l_j)$ and $P_k(r_k, l_k)$ are collected.

$$r_j \approx r_k, \quad r_j \approx r_k + j, \quad r_j + j \approx r_k, \quad r_j + j \approx r_k + k$$

**Final adjustment.** There still are some candidate pairs that should not be a repeat component. To see this, suppose that A and B comprise a candidate pair. If A includes an identified repeat component X, B should include the same repeat component; however, if B has a different repeat component P (and no X), then the pair of A and B is a wrong candidate pair. The pairs can not become repeat components and are omitted. All candidate pairs should be checked for this kind of nesting condition. A candidate pair that does not satisfy the correct nesting condition is omitted.

Two kinds of candidate pair have a high probability to be a repeat component:

1. those collected in the previous process, and
2. those whose length is long but whose average distance, i.e., $\bar{D}_j(r, l)$, is small.

These candidates are given priority, whereas the rest of the candidate pairs have to be checked for the nesting condition one by one. It is clear that the correctness of the first type of pair is reliable. For the second, the longer the candidate pair, the greater the probability that the pair will be correct repeat component.

Each repeat component is given a component number. The number is assigned to all the frames that belong to the component. The correctness of the nesting condition
is checked with respect to the distance calculated with the component numbers between the frames in the pair. A small distance means that the pair includes the same repeat component or the pair includes no repeat component. Thus, the pair passes the nesting condition check and is determined as a correct repeat component. The component number of the \( r \)-th frame is represented as \( n(i) \). The nesting condition distance \( C_J(r, l) \) for a candidate pair \( P_j(r, l) \) is calculated as follows.

\[
C_J(r, l) = \sum_{r=1}^{\frac{r+1}{2}} |n(i) - n(i + j)| \quad (11)
\]

Regarding the previous example, suppose that the component number of \( X \) is 1 and that of \( P \) is 5. The pair of \( A \) and \( B \) is detected in either case 1 or case 2 shown in Fig. 3. In case 1, although parts that include \( X \) are slightly different from each other, because of the sameness of the included repeat component, the value of \( C_J(r, l) \) is 0.2. This is small enough for the pairs to be deemed a new repeat component. On the other hand, in case 2, although the parts that include \( X \) or \( P \) are the same, because of the difference of the included repeat component, the value of \( C_J(r, l) \) is 2.8. This is too big for the pair to pass the nesting condition.

The pair that is determined as a new repeat component is assigned a new component number. The frames that belong to the new repeat component but have no component number as yet are assigned the new number to prepare for the following nesting condition check for the next pairs.

If \( A \) is included only in a repeat component \( Y \) and \( B \) is included only in a repeat component \( Q \), a part of \( Y \) might be similar to a part of \( Q \). Thus, in this case, although the nesting condition distance is large, \( A \) and \( B \) are determined as a new repeat component.

3.2.2 Visualization

Each repeat component is assigned a single color. The colors are painted on the base image described in Section 3.1. If the components are nested, two colors are painted alternately (stripes). Moreover, if the repeat component is repeated directly after it finishes, black is used to emphasize the end and the start of these components.

4. TARGET MUSIC ANALYSIS

Three pieces of music were visualized with the method described in Section 3:

- Case 1
- Case 2
- Candidate pair A/AB
- Candidate pair B/AB

Table 1: Repetitions in BU

<table>
<thead>
<tr>
<th>Repetition</th>
<th>Performance (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/2 - 124</td>
</tr>
<tr>
<td>2</td>
<td>37/16 - 58</td>
</tr>
<tr>
<td>281 - 326</td>
<td>273.9 - 286</td>
</tr>
</tbody>
</table>

1. The first movement, "allegro con brio", in Symphony No. 5 in C minor, Op. 67 composed by Beethoven.
3. "Yesterday" by The Beatles.

I selected these pieces because they are famous, with good music scores available. In this section, I analyze the target pieces as to their structure on the basis of their music scores, which formed the basis of the experimental evaluation.

4.1 Symphony No. 5 by Beethoven

Acoustic data was extracted from a CD [18] of a performance by David Zinner, conductor, and the Tonhalle Orchestra, Zurich. I call this piece "BU" hereafter in this paper. The first movement is in big sonata form [1, 6]. The number of bars and the performance times of each part are as follows.

1. Exposition: from the 1st to 124th bar, [a] performed from 1.6 to 79.9 seconds and [b] from 79.9 to 138.6 seconds.
2. Development: from the 125th to 247th bar, performed from 158.6 to 233 seconds.
3. Recapitulation: from the 248th to 374th bar, performed from 233 to 328 seconds.
4. Closing section: from the 375th to 502nd bar, performed from 328 to 406 seconds.

The Exposition is performed twice, and the other parts are performed once. The Recapitulation has melodies similar to the Exposition but in different keys. The part from the 37th to 58th bar in the Exposition is almost the same as the part from the 281st to 302nd bar in the Recapitulation in the music score. Table 1 shows the repetitions that should be detected.

4.2 Eine Kleine Nacht Musik by Mozart

The acoustic data was extracted from a CD [1] of a performance by Herbert von Karajan, conductor, and the Berliner Philharmoniker. I call this piece "ME". The first movement is in sonata form [6, 9, 16]. The number of bars and performance times of each part are as follows.

1. Exposition: from the 1st to 55th bar, [a] performed from 1.6 to 90.8 seconds and [b] from 90.8 to 180 seconds.
2. Development: from the 56th bar to the 75th bar, performed from 180 to 213 seconds.

Unfortunately, the CD number is unknown.
3. Recapitulation: from the 76th to 131st bar, performed from 213 to 304 seconds.
4. Closing section: from the 131st to 137th bar, performed from 304 to 316 seconds.

The Exposition is performed twice and the other parts are performed once. The part from the 76th to 98th bar in the Recapitulation is almost the same as the part from the 1st to 23rd bar (the so-called first theme) in the Exposition. Moreover, the part from the 35th to 42nd bar in the Exposition is subsequently repeated (from the 43rd to 50th bar). Table 2 shows the repetitions that should be detected.

### 4.3 Yesterday by The Beatles

The acoustic data was extracted from the CD entitled “The Beatles: 1962 – 1966” [19]. I call this piece “BY”. This song contains two melodies as follows [24].

1. First melody:
   (a) from the 3rd to 9th bar, performed from 5.5 to 22.5 seconds (accompanied only by the guitar).
   (b) from the 10th to either of 16th or 16th, 26th and 27th bars (accompanied by the guitar, violin, and so on), performed
      i. from 22.5 to 30.8 seconds
      ii. from 59.5 to 77.3 seconds, and
      iii. from 97.3 to 122 seconds (16th, 26th and 27th bars)

2. Second melody: from the 17th to either the 24th or 25th bar, performed
   (a) from 29.8 to 39.5 seconds (the 23rd and 24th bars)
   (b) from 77.3 to 97.3 seconds (the 23rd and 25th bars)

The first melody is performed four times. The first performance of the melody is accompanied only by the guitar. The rest are accompanied by the guitar and other instruments. This is the reason the first performance of the first melody feels a little different from the rest of the performance. The fourth performance of the first melody adds a short different melody just after the last bar. The second melody is performed twice; however, the last bar of each is different. Table 3 shows the repetitions that should be detected.

### 5. EXPERIMENTAL RESULTS

The experimental results were obtained from the CD’s, acoustic data was taken in monaural WAV format with a 44100-Hz sampling rate and 16-bit quantization. The acoustic data was processed with an FFT whose window size was 32768 points shifted at 4410-point intervals. The number of filter banks for calculating the MFCC vectors was 24. The vectors had 16 dimensions. The Euclidean distance was used to calculate similarity between the vectors. Table 4 lists the values of the parameters described in Section 3.2.1. All parameters were determined from pilot experiments and previous research [4].

#### 5.1 Volume Transitions

Figure 4 shows the smoothing results for the power data. The solid line represents the smoothing results; the dotted line represents the raw power data.

#### 5.2 Repetition Identification

Table 5 shows the repetition identification results. Regarding BU, the parts that correspond to the Exposition and the parts that appear three times in both the Exposition and the Recapitulation were detected. Regarding ME, the parts that correspond to the Exposition and the parts that appear three times in both the Exposition and the Recapitulation were detected. However, the short repetitive parts in the Exposition were detected as different repeat components. These results indicate that the algorithm for collecting candidate pairs as repeat components should be improved by introducing more rules and another distance calculation, such as one based on an interval-to-interval calculation instead of a frame-to-frame calculation. Regarding BY, two kinds of repeat components were detected. The repeat components that correspond to the first melody were detected three times, and the repeat component containing the first and second melody were detected twice. Thus, the second

![Figure 4: Smoothed power data with k set to 100.](image-url)
5.3 Visualization Results

Figures 5, 6, and 7 show MusicLab's visualization results for the pieces described in Section 4. The x-axis represents time, and the y-axis the volume. The units of time and volume in all figures are the same, so that the three pieces can be directly compared with each other. Same-colored parts are performed repetitively in each piece of music. Parts that belong to two kinds of repeat components are presented with stripes. Gray means there are no repeat components. The colors themselves have no meaning in this work at present.

5.4 Discussion

5.4.1 Symphony No. 5 by Beethoven

Figure 5 shows the visualization result of BU. In regard to the volume transition, it is clear that this piece starts loud. Some listeners may feel a strong impact at the beginning. There are big differences in volume all through the performance; however, the entire final part is performed at a loud volume. Thus, some listeners might keep an uplifted mood after the performance.

In regard to repetition identification, it is clear that there are two kinds of repeat components in the piece, since there are two colors, orange and blue. There are few repeat components in spite of the length, and one of the repeat components (blue parts) is very short. Thus, it seems that it may be a little difficult for us to recall the piece and to feel affection for it.

Based on the analysis in Section 4.1, the orange parts are the Exposition. We can definitely see that the Exposition is performed twice, since there are two orange parts and their shapes are very similar. Two blue parts are included in the Exposition (depicted as stripes of orange and blue). To give the same impression for the last blue part that belongs to the same repeat component, it is also depicted as stripes. Thus, people can intuitively imagine that there is a part that is performed three times in this piece.

From this visualization, we can intuitively imagine that the volume of this piece varies wildly, and there are only two repeat components: a long one performed twice and a short one performed three times.

5.4.2 Eine Kleine Nacht Musik by Mozart

Figure 6 represents the visualization result for ME. In regard to the volume transition, it is clear that this piece also starts at a large volume and the volume changes frequently. Since the changes in volume transition can also be seen in the final part, people may imagine that ME does not have a powerful strong-aftereffect compared with BU.

In regard to repetition identification, we can see that there are four kinds of repeat components in the piece, since there are four colors: green, red, yellow, and blue. There are many repeat components. Thus, someone might imagine that it would be easy to memorize the piece and also be affected by it.

Based on the analysis in Section 4.2, the green parts are the Exposition. We can see that the Exposition is performed twice, since there are two green parts and their shapes are very similar. Moreover, we can see that a part of the green part (red part) is also performed in the latter part.

From the visualization, we can intuitively imagine that the volume of this piece varies wildly, and there are four repeat components: a long one performed twice another one performed three times, and two others that are very short and performed subsequently in the first repeat component.

5.4.3 Yesterday by The Beatles

Figure 7 represents the visualization result for BY. In regard to the volume transition, it is clear that this song starts very quietly. Some people might imagine that it would be nice to listen to this song for a calming effect. Moreover, it is clear that there is little difference in volume throughout the piece. This is a typical feature of pop hits with vocals. Most musical pieces with vocals (songs) generate cylinder-like images, since the parts with vocals continue at higher volume. Volume tends to fall during instrumental parts. Thus, we can imagine that this song has lyrics for almost all parts, since the volume does not fall.

In regard to repetition identification, it is clear that there are two kinds of repeat components in the piece, since there are two colors, yellow and blue sky. The beginning part in gray has the same melody as the part in sky blue, however, different instruments are used. If the beginning part were represented in a color similar to sky blue, we would easily see that this song contains two melodies (yellow and sky blue) and is constructed with two patterns (sky blue and yellow-sky blue). Then, many people would be surprised that the structure of this very popular song is so simple.

From this visualization, we can intuitively imagine that there are two repeat components: one is performed three times and another performed twice.

5.5 Summary of Experimental Results

Regarding the volume transition image, the shape tells us whether the piece contains vocals or not. For example, the shape of BY, which has vocals, seems like a cylinder (Fig. 7); however, the shapes of BU and ME, which are a symphony and an orchestral work, are bumpy (Figs. 5 and 6). Generally speaking, when the volume of music with vocals is plotted, the shape of the vocal part is cylindrical. The reason for this may be that the role of lyrics and words is to convey a message, whereas, the reason that the volume of symphonies varies may be that people enjoy an ensemble of instruments that change their timbre.

Regarding identification of the repetitive parts, color vi-
6. FUTURE WORK

Music information visualization is a big challenge. I would like to find and extract more features and visualize them in a form that suits people’s intuition.

Regarding volume transition, the maximum volumes of these three pieces seem almost the same when we look at the images in Figs. 5 to 7. However, people would certainly feel more volume and power from the symphony and the orchestral work than from “Yesterday”, even if “Yesterday” was continuously performed at a relatively high volume. Why is this? It is known that the physical power of sound is not the only factor to affect people’s sensitivity to volume [17]. Thus, volume transition visualization based on such knowledge should be investigated in the future.

Regarding the repetition identification, repeat components can be extracted without fail with the algorithm presented in this paper for many pieces of music; however, the methods for collecting candidate pairs that come from the same repeat component to a single repeat component together should be improved and the final adjustment should be fine-tuned. Moreover, each of the approaches described in Sec. 3 use many parameters, such as thresholds. As all parameters are determined on the bases of experimental results, further refinement of them is needed. The methods and parameters need to be given more appropriate descriptions based on statistical data obtained through experiments with more pieces of music. Such explanations will also yield fundamental knowledge regarding how people listen and understand music.

Visualizations of different music were presented here. It would be interesting to compare visualization results for the same piece performed by different conductors and performers. We can imagine the focuses and policies of the conductors and performers would be discernible by looking into the performance time and volume in detail, since classical music varies according to them. Thus, it seems possible that we might be able to extract and visualize not only musical features but also performance features in the future.

7. CONCLUDING REMARKS

This paper described a method of visualizing music, called Misual, with the focus on volume transitions and musical structure based on repetitions. The volume transitions were visualized as a 3D-like image of continuous circles whose radii represent volume. By viewing the volume transition image, it is possible, for example, to imagine whether a piece of music contains vocals. The parts performed repetitively were visualized with colors. Each repeat component was allocated a particular color and painted on the volume transition image. By viewing the location, length, and number of repetitive parts, it is possible, for example, to imagine whether a piece of music would be easy to remember. It is clear that providing music images generated from acoustic data is objective, in other words, not biased by anybody. This makes it possible for people to imagine how a piece of music might sound on the bases of their own sense. That is, defining musical features that help people to imagine how a piece of music sounds, visualizing such features in a way that suits human intuition, and motivating people to think about a piece of music with joy are the final goals of this music visualization research. In this work, some musical features were extracted and visualized in a 3D-like color image.

8. REFERENCES


[18] CD number: BVCE88002.

[19] CD number: T0CP51127.
