1. Concept
We developed a moving points animation system called Constellation using the characteristics of visual perception that allow interpretation of three-dimensional structure from the motion of points. Human beings can reconstruct the structure of an object from two-dimensional moving images that are digitized over time ("Structure from Motion") [1]. Ullman et al. showed that it is possible to recognize the structure of an object by observing four points on a moving object three times [2]. These characteristics of human visual perception can be exploited to offer representations that stimulate the intellectual curiosity of users by quickly changing the shape of a character or morphing it into another object.

2. System
Fig. 1 shows an actual example displayed by the Constellation. A character formed of multiple points moves with the goal of reaching a destination that the system randomly assigns. When the character reaches the destination, it moves towards a newly assigned destination. Various types of characters are possible, such as humans, dogs, and birds. Points that do not form constituent elements of characters represent stones on the ground. Points constituting characters are displayed as white, and stones are displayed as gray. The user can create stones or characters, delete points, and rotate the viewpoint by selecting icons arranged at the right of the screen. It is also possible to continuously change the viewpoint automatically. Because characters have no surfaces, the user understands their structure from the motion of their points. The intellectual curiosity of the user is thus stimulated by changing the meaning of the points while maintaining the character's position on the screen. This representation, which we call "perception morphing", offers users new perceptive experiences. We describe a number of perception morphing below.

2.1 Creation
A new character is created from multiple points (Fig. 2).

2.2 Shape changing
Some of the points forming the character are replaced with stones or part of another character (Fig. 3).

2.3 Morphing
Another character is created from points forming an existing character, or both stones and points forming a character (Fig. 4).

2.4 Destruction
A character from which constituent points are missing is destroyed (Fig. 5). Destruction occurs when the user deletes points forming a character or when the points forming it are used for another character.

3. Technical Trick
A character recognition process in this system involves matching the positions of a group of points on the screen and a group of sample points serving as a reference. To enable real-time operation, the system performs the matching process for all groups of points in the order human, dog, and bird, and when it finds a match for one character, it does not perform matching for the next character. The character matching process randomly selects one frame from all animation frames which are registered in advance. Next, the points forming the character in the selected frame are rotated by 20 degrees to perform perspective transformation. All points on the screen are subjected to matching processing, with a group of points serving as the sample points, and the matched group of points is then converted to three dimensions. A match is recognized if the distance from the sample points is up to 8 pixels, and the points are converted to three dimensions while maintaining the error between pixels.

4. Conclusion
In this paper, we introduced a point animation system known as Constellation, which uses the characteristics of human visual perception that allow recognition of an object's structure from the motion of the points, and we described a so-called perception morphing. Constellation is available for use on our website [3] and runs on web browsers with Java Runtime installed. We believe that perception morphing will offer users new perceptive experiences.

5. References