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RENDERING OF WATER SPLASH

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ABSTRACT

We propose a simple method for rendering water splashes occurring on object's surface. Based on the result of having analyzed movies which recorded experiments of dropping waterdrops, we create three types of models of the water splash. The proposed method allows us to do the followings; (1) Generation of the water splash for which the material and the wetting condition of the waterdrop-landing surface are reflected. (2) Calculation of the orbit of the water splash considering with the influence of the gravity and the air resistance. (3) Generation of the water splash which reflects the incident direction of the fallen waterdrop. We confirmed the usefulness of the proposed method through generating animations.

KEYWORDS

Computer graphics, Rendering, Natural phenomena, Rainy scene, Water splash.

1. INTRODUCTION

In order to generate the highly realistic rainy scene through computer graphics, expression of not only the trajectory of the raindrop itself but also the water splash generating on the surface is important. In a landscape image, the expression of the rain rarely plays the main role, and secondary phenomena, such as the water splash which arises by rain, draw a still lower attention. However, if we express these secondary phenomena in rough way, the total quality of the image will be spoiled remarkably. Consequently, the method for expressing of the water splash is required to satisfy both the low calculation cost and the good image quality. In order to solve this subject, Feng et al. proposed a simple-rendering model of the water splash which used the image sequence of the real water splash [1]. This method firstly detects the location where a raindrop hits on the ground. Then a plane on which the image sequence of the water splash is drawn is set according to both the direction of the view-line and the normal vector at the colliding position. This method also allows us to change attributes of a water splash, such as the size and the shape. Since this method is based on the cartoon style expression, however, it cannot provide enough quality of the water splash for the landscape image. Moreover, this method does not take into account neither the material nor wetting condition of the surface on which the water splash occurs. Chang et al. proposed a real-time method for rendering splash of stream water overirregular terrain [2]. This method employed GPU-based particle system to simulate dynamics of water and use 2D metaballs with billboards to express the 3D shapes of water. Tatarchuk et al. proposed a method for fast generation of the rainy scene including the water splash by using the image sequence [3]. This method allows us to reflect the brightness of the surrounding to that of the water splash through considering the change of the intensity of the ambient light. Sakamoto et al. proposed a method for expressing the water splashes generated by a tire passing through a puddle [4]. In this method, the depth of the puddle was taken into account at the time of generation of the water splashes. Thornton proposed a method to create stylized splashes [5]. The user can control the shape of splash through this method. However, all of the above mentioned methods include the common problem that they can express only a single shape or pattern of the water splash.

On the other hand, methods for expressing motion of the liquid based on CFD (computational fluid dynamics) which employs the finite element method or the particle method have been proposed [6,7,8]. This method is able to do high quality expression of the phenomena on the water surface such as the ripple transmission and the fluctuation. Here, when we treat the water splash as the element of the rainy scene and use a CFD based method to express the water splash, it is supposed that we can seldom obtain the visual effect which corresponds to the calculation cost. That is, the CFD based methods do not suit for generating a scene such as walk-through in the rain. Thus, we may conclude that no method for expressing the water splash with enough visual effect has been proposed. Then, we firstly carried out experiment of water splash generation under plural combination between the size of waterdrop and the wetting condition of the surface and recorded with high-speed camcorder. We made clear the relationship between the formation of the water splash and the condition of the surface (it consists of the material and the wetting condition) through analysis of the obtained movies. Based on the results, we will propose a model for expressing water splash in CG which achieves well balanced trade-off between the calculation cost and the visual effect.

2. ANALYSIS OF WATER SPLASH

2.1 Experiments

Since the water splash phenomena changes momentarily, it is difficult for us to recognize water splash's shape, size, and the situation of change clearly. Moreover, like the case of looking at water splashes which arise on a road surface, it is easily expected that we cannot perceive the detailed change of a water splash because of its minuteness even if we reproduce the precise process of water splash.

Based on the above fact, we carried out experiments to investigate items whose visual influences are supposed to be comparatively large. They were (a) the shape of the water splash just after collision, (b) the trajectory of the dispersing waterdrops, (c) the scale (size) of the water splash immediately after collision, and (d) the situation of the surface on which the water splash happens. In order to catch and analyze a momentary phenomenon, we used the high-speed photography camera (Kodak Ektapro HS4540, image size: 320 dots wide by 240 dots high, recording speed: 500 fps).

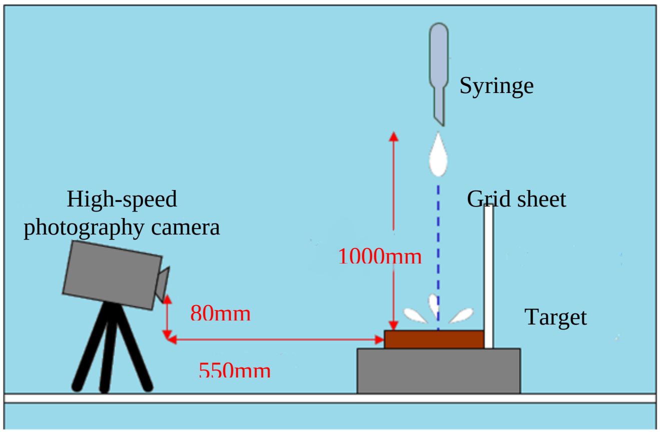


Figure 1. Experiment environment

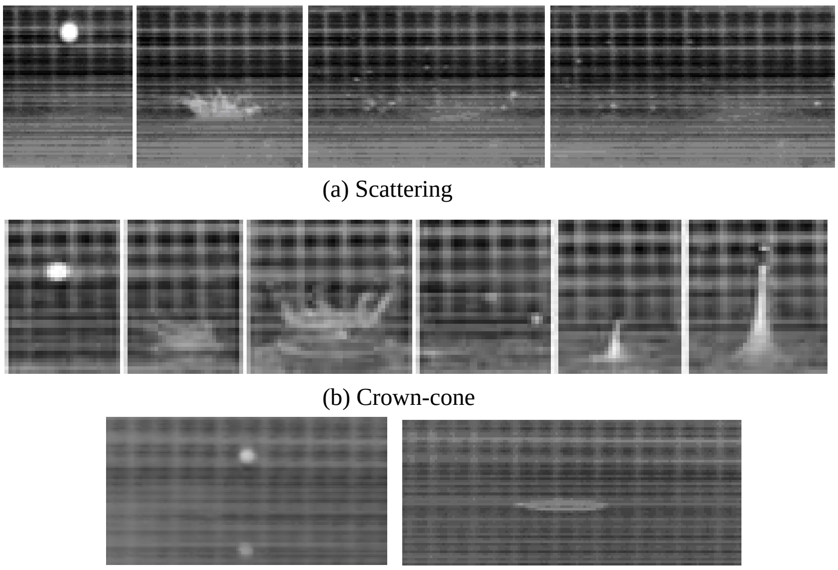
We carried out experiments of dropping waterdrops from a syringe to the target. Figure 1 depicts an experiment environment. The tip of the syringe was set at 1 meter height and we used several sizes of tip of the syringes. In order to record the water splash on the conditions which combined two or more factors, we conducted the experiment through combining the size of the waterdrop, material of the surface of the target, and wetting situation of the surface on which the water splash occurs. The size of the waterdrop was one of "large, medium, or small". The material of the surface of the target was also one of "concrete, asphalt, or griddle". And the wetting condition of the target's surface was one of "dry, wet, or puddle". Where the situations of the surface "dry" and "puddle" mean completely dry and having the depth of water more than the threshold, respectively. The "wet" situation means the situation between the "dry" and the "puddle".

2.2 Analysis of Experimental Result and Its Consideration

When a waterdrop or a particle solid collides with the water surface, generally the shape of the water splash is considered to become a so-called milk crown. Therefore, except for the technique based on the CFD, many techniques for expressing a water splash had employed the method adjusting the size of a milk crown [1, 3, 5]. This experimental result showed that a water splash which is generated just after collision could roughly be classified into three patterns, scattering, crown-cone, and disk. Typical examples of image sequences are shown in

Figure 2. As shown in Figure 2 (a), the "scattering" water splash model consists of a sequence that begins with piles spreading out like flame then each tip of the pile detaches a waterdrop and then the waterdrop disperses. As shown in Figure 2 (b), the "crown-cone" water splash model consists of a sequence that begins with a round-shaped curtain then the tip portion spreads to crown-shape (this is the so-called milk crown). After the tip portion falls down to the surface level the cone-shaped water splash comes up and then it goes down. As shown in Figure 2 (c), the "disk" water splash model consists of a sequence that the waterdrop collapses on the surface and then it spreads to a disk-shape. In each splash pattern, the parameter of the water splash, such as dispersing number of waterdrop, the degree of ejected angle, the height of a conical water splash, and the radius of a disk, changes with the sizes of the fallen waterdrop.

When the wetting condition of the fallen surface is "dry", the waterdrop which collided with the fallen surface (except for the griddle) seeps into the object, without forming a water splash. In case of "wet", it turned out that a water splash is not generated on the concrete with enough moisture while the "scattering" pattern of water splash is generated on the same situation of the asphalt. The reason of this fact is supposed as follows: the surface of an object made of asphalt has more roughness than that made of concrete and this is considered that a small amount of water is already accumulated depending on the place where waterdrop falls. When the film of water has stretched on the surface, the "scattering" pattern of water splash is generated on the asphalt and concrete. The intensity of water splash is easily generated on asphalt than that on concrete because of its greater surface roughness. If the situation of collision surface becomes a puddle of 10 mm or deeper depth, the "crown-cone" pattern of water splash is generated regardless of the material of the surface.



(a) Scattering

(b) Crown-cone

(c) Disk

Figure 2. Examples of water splashes photographed by the High-speed camera

3. OUTLINE OF THE PROPOSED METHOD

3.1 Basic Ideas

As mentioned above, the water splash which is a momentary phenomenon rarely gets focused on in a rainy scene and we consider that improvement of the total quality of the animation cannot be obtained through consuming the calculation cost for expressing accurate move of the waterdrop and water surface. So, in this paper, we aim at developing an expression method of the water splash with high visual effect under low calculation cost by adopting a simple model. Concretely, we develop a method of enabling generation of a water splash which suits the collision point of the raindrop through changing the applied water splash pattern according to both the material and the wetting condition of the collision point. In order to realize it, we also develop a system which allows us to store and update the parameters (the material and the wetting condition) on the collision surface.

3.1.1 Generation of the Water Splash

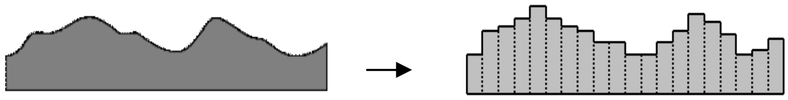
As we had shown in the result of our experiment in the previous section, the water splash does not usually forms the milk-crown but it becomes quite complicated shape. However, as mentioned in the previous section, we estimate that improvement in the quality corresponding to the calculation cost for reproducing this complicated shape cannot be obtained. So, in order to reduce the calculation cost, we employ the method of drawing the minimum number of polygon for expressing the water splash. On the other hand, relating to the shape change of a water splash or the dispersing motion of a waterdrop, we apply different parameter for calculation for each water splash or scattering waterdrop corresponding to generating conditions of them. This way allows us to generate the water splash with non-uniform and high visual effect.

3.1.2 Management of Wetting Condition of the Road

The water splash occurs through a fallen waterdrop colliding with an object's surface. From the result of the experiment, it has been obvious that there is a close relationship between the shape of a generated water splash and the condition of the object's surface. As shown in Figure 3 we subdivide the object's surface (assuming it is a flat ground) into square cells and manage information including minute unevenness at each cell [4]. We developed a framework consisting of the following processes: store the material and the wetting condition for each cell; suitably update the wetting condition; reflect the wetting condition of the collision point to the generation of the water splash. These processes allow us to generate a water splash which is suitable to the condition of its collision point.

3.2 Premise and Restriction

Since proposed method is premised on application to the walk-through or the drive-through, we assume the water splash which is generated in the large area and high frequency. Furthermore, since we employ simple water splash model based on giving the priority to the visual effect versus calculation cost, the proposed method is not suitable for rendering a scene for investigating a single water splash by close-up.



(a) Base ground surface (b) Subdivided cells corresponding to (a)

Figure 3. Cell subdivision of the ground surface

The aim of the proposed method is to express the water splash which occurs just after a waterdrop collides on the object's surface. Moreover, the proposed method is carried out on the premise that the following information about a waterdrop has already been known when the waterdrop arrives at the object's surface. They are position, incident vector, and size. When taking the influence of a wind into consideration to expression of the raindrop's trajectory [9], the wind distribution used for the calculation of the raindrop's trajectory is used also for orbital calculation of a water splash.

The orbit of the dispersing waterdrop or the sharp-pointed water splash is calculated in consideration of the gravity and the air resistance. Consequently, it is possible to reflect the size and speed of waterdrop into the orbit calculation, and it allows us to avoid becoming a uniform expression. Since the object surface which a water splash generates is divided in square cells as mentioned above and height information is managed by each cell, the roughness of surface of an object cannot be reflected precisely. That is, the roughness on the surface of an object smaller than a cell is disregarded. A close relation also exists between the wetting condition on the surface of an object and the shape of a water splash. On the other hand, the detail part of a water splash is expressed by giving random numbers to parameters, such as initial velocity and the degree of angle of emergence. In the proposed method, the wetting condition is classified according to "dry", "wet", and "puddle" (the depth of the water of 3mm, 5mm, and 10mm), and the range of a random number is changed for every wetting condition.

4. COMPUTATION MODEL FOR THE WATER SPLASH

4.1 Scattering Water Splash Model

As shown in Figure 4, we use a quadrangular pyramid to express the pile-shape water splash and also use a sphere to express the dispersing waterdrop in the scattering water splash model. The generation procedure according to this model is described in the following.

(1) We determine the number of the waterdrop which disperses from the fallen surface according to the situation of the surface and give initial velocity to each waterdrop (see Figure 4 (a)).

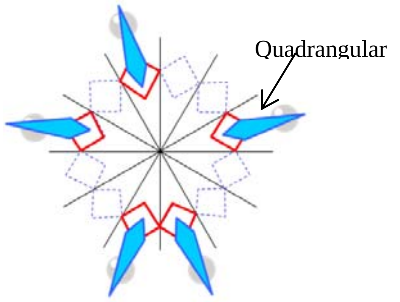
(2) We determine dispersing direction of the waterdrop under the assumption that both the azimuth and elevation angle respectively follow a normal distribution (see Figure 4 (b)).

(3) We determine the radius of the initial circle according to the situation of the fallen surface as shown in Figure 4 (c) and arrange the bottoms of quadrangular pyramids on the circumference (depicted as red quadrangles in Figure 4 (c)).

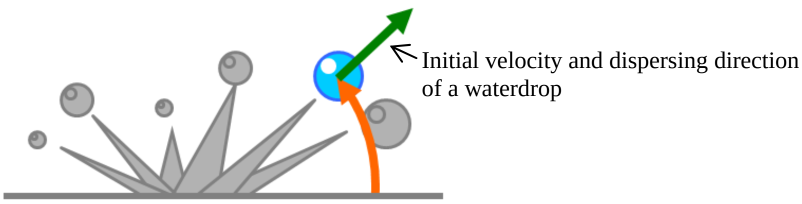
(4) From the analysis results of an experiment, it has become clear that the dispersing waterdrop is come from the top of a pile-shape water splash. Based on this knowledge, we assume that the direction and velocity at which the tip of a pile-shape water splash is extended and those of a waterdrop which is separated from it are equal. Consequently we reproduce the motion of the pile-shape water splash through making the trajectory of the tip of the quadrangular pyramid the same as that of the scattering waterdrop as shown in Figure 4 (d).

(5) After the waterdrop collides with a surface, plural quadrangular pyramids which correspond to the pile-shape water splash are rendered, and if they exceed a unit time interval or a unit distance from the start point, they stop growing and generate a small sphere which represents a water drop and will move on the orbit which corresponds to the trajectory of the tip of the quadrangular pyramid, as shown in Figure 4 (d). At this time, we compute the trajectory of the tip of a quadrangular pyramid and the orbit of a sphere considering the effect of the gravity and air resistance.

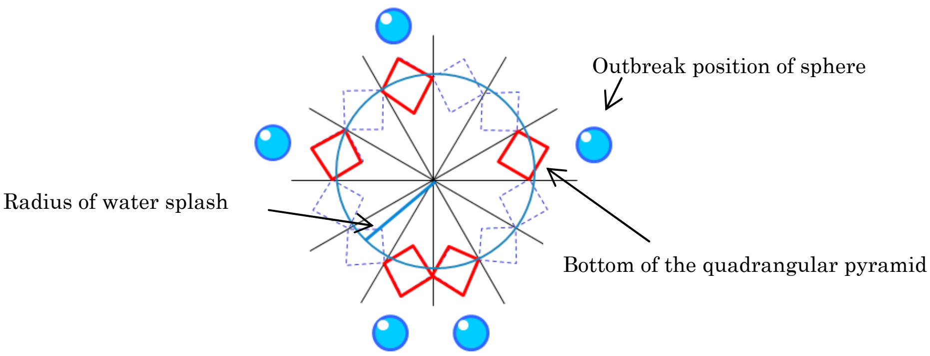
Here we assume that the falling velocity of a waterdrop just before colliding with the object surface is known and we can express waterdrop with incident directions other than the perpendicular direction through reflecting the falling velocity to the orbit calculation of a water splash.



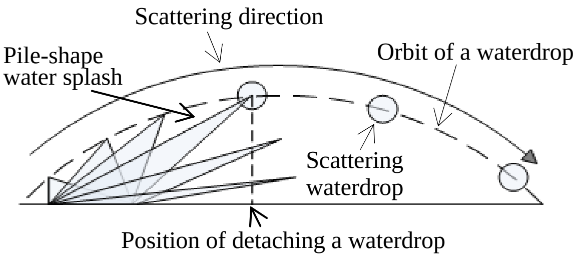
(a) Determination of the number of dispersing waterdrops



(b) Initialization of velocity and direction



(c)Decision of the position of quadrangular pyramid

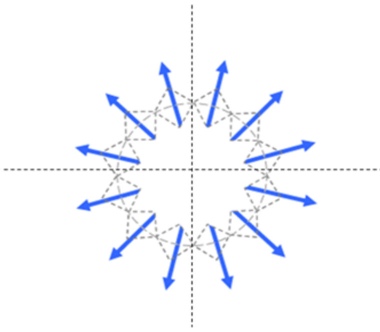


(d) Orbits of a tip of a pile and a waterdrop

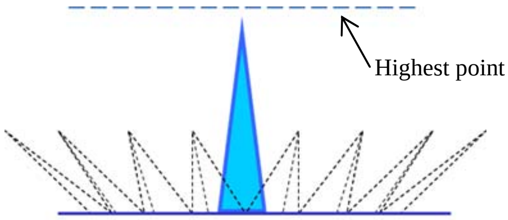
Figure 4. Scattering water splash model

4.2 Crown-cone Shape Water Splash Model

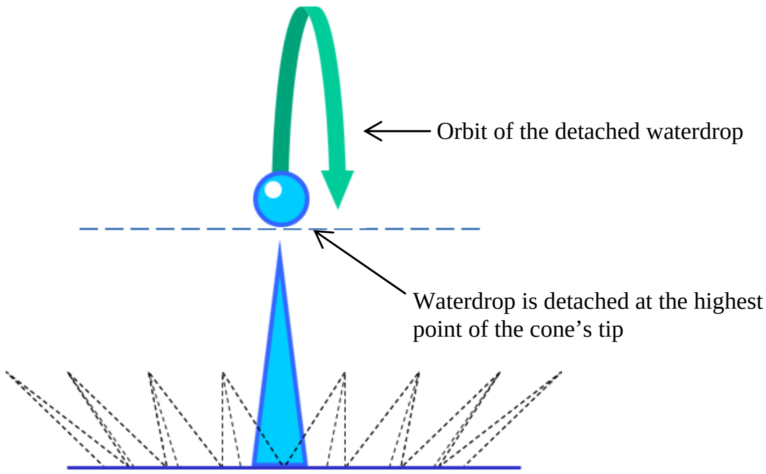
In the proposed crown-cone model, a crown-shape water splash appears first (rises up and falls down), then a cone-shape water splash rises, finally a waterdrop separates from the tip of the cone at the peak of the rising. We represent the cone-shape water splash and the waterdrop separating from it by using a quadrangular pyramid and a sphere, respectively. The generation procedure according to this model is described with referring to Figure 5.



(a) Crown-shape water



(b) Cone-shape water splash



(c) Detached waterdrop and its orbit

Figure 5. Crown-cone shape water splash model

(1) The crown-shape water splash is so-called milk-crown. It is complicated shape as shown in Figure 2 (b) and its existence time is short compared with the cone-shape water splash. Therefore, we represent it through drawing plural quadrangular pyramid radiately. More specifically, all quadrangular pyramids prepared for the scattering model are used to represent the crown-shape as shown in Figuer 5 (a). Initial conditions for drawing the crown-shape splash are given by the attributes of a fallen waterdrop.
(2) After disappearance of the crown-shape water splash, a quadrangular pyramid is drawn at the center of the crown circle. We decide the initial rising velocity of a cone-shape water splash (which is reflected on growing a quadrangular pyramid) and the radius of the waterdrop to separate according to the size of a falling waterdrop and the wetting condition of the colliding surface. The highest point at which the tip of the pyramid arrives (see Figure 5 (b)) is given by the initial condition according to the fallen waterdrop.
(3) A sphere is separated at the place where the tip of the pyramid reaches the highest point as shown in Figure 5 (c). Then the sphere moves in the space. Here we employ the same orbital calculation method as the scattering model, however, we limit its moving direction in the perpendicular direction.

4.3 Disk-shape Water Splash Model

In the disk-shape water splash model, there is no splash and a disk appears on the waterdrop fallen surface in an instant. It appeared only on the dried steel panel in our experiments. Fallen waterdrop does not sink in, but it remains at the colliding position, we draw the disk as a circle which is drawn with the radius decided by the size of fall waterdrop after a collision.

4.4 Orbit calculation of Waterdrop Generated for Water Splash

When we calculate orbit of the tip of the pile-shape water splash, the dispersion waterdrop, the crown-shape water splash, and the separated waterdrop, it is assumed that every movement is regarded as that of a very small particle. The effect of the gravity and the air resistance are also considered in this calculation. In this paper, we calculate their orbit through the following equation (the horizontal direction is set to x axis and the perpendicular direction is set to y axis) as an orbit of an obliquely-upward-thrown object.

$$\begin{aligned} x(t) &= v_0 \cos\theta \left(-\frac{m}{F}\right)\left\{\exp\left(-\frac{F}{m}\right)t - 1\right\} \\ y(t) &= \left(v_0 \sin\theta + \frac{mg}{F}\right)\left(-\frac{m}{F}\right)\left\{\exp\left(-\frac{F}{m}t\right) - 1\right\} - \frac{mg}{F}t \end{aligned} \quad (1)$$

where, v_0 is the initial velocity, θ is the shooting-out angle (elevation angle) of the waterdrop, and m is the mass of waterdrop, F is the air resistance, g is the acceleration due to gravity, and t is elapsed time. The initial velocity, the shooting-out angle, and the mass of the waterdrop are randomly given based on the range of value obtained through our experiment. The air resistance F is obtained by the following equation.

$$F = \frac{1}{2} C_d \rho V^2 S \quad (2)$$

where, C_d is the drag coefficient, ρ is the density of the fluid (air), V is the relative velocity of waterdrop against the air, and S is the representation area of the waterdrop. Since equations (1) and (2) show that the amplitude of the air resistance is affected by the velocity and the size of the waterdrop and they become the parameter of the orbit calculation, we obtain the drag coefficient through not generation of random number but calculation which reflects the attributes of waterdrop. We calculate the drag coefficient C_d using the following equation.

$$C_d = \left(0.55 + \frac{4.8}{\sqrt{\mathrm{Re}}}\right)^2 \tag{3}$$

where Reynolds number Re is a non-dimensional number defined by the ratio of force of inertia to viscous power and is obtained by the following equation.

$$\mathrm{Re} = \frac{UL\rho}{\mu} \tag{4}$$

U is the typical speed of fluid, L is the typical length of waterdrop, and μ is the coefficient of viscosity. Since F is equal to $-ma$, if we consider the direction, the acceleration $a(t)$ of the waterdrop in the time t is denoted by the following equation.

$$a(t) = -\frac{C_d \rho S}{2m} V(t) \tag{5}$$

According to equations from (2) to (5), velocity of the waterdrop at time t_{k+1}, $V(t_{k+1})$, is denoted by the following equation by using the minute interval Δt .

$$V(t_{k+1}) = V(t_k) + a(t_k)\Delta t \tag{6}$$

From this equation, the position of a waterdrop at time t_{k+1}, $P(t_{k+1})$, is calculated by using the following equation.

$$P(t_{k+1}) = P(t_k) + v(t_k)\Delta t + a(t_k)\Delta t^2 / 2 \tag{7}$$

4.5 Consideration of the Influence of Incident Direction of a Waterdrop and Wind Direction

In previous explanations, we assumed a waterdrop which falls in the perpendicular direction. However, the actual rain considered to be a candidate for application of the proposal method draws various trajectories by external factors, such as a wind. Thereby, the shape of a water splash is also changing. So we simply render the shape of water splash except for falling in the perpendicular direction. At this time we set premise that the direction and velocity of wind in a simulation domain are known. Figure 6 shows the process flow of calculating orbit of the spray waterdrop in consideration of the incident direction of fall waterdrop and the influence of a wind. After we determine the collision point of the waterdrop, we determine the parameter of a water splash by using attribute information on a corresponding cell. And the wind vector which is blowing in the air over the cell is obtained, and it is reflected on orbital calculation of a water splash. Thus, we can simply and effectively render the water splash which can respond to the waterdrop which falls from other than the perpendicular direction, that is the waterdrop which falls under the environment of blowing wind.

4.6 Relationship between the Wetting Condition and Water Splash

4.6.1 Management of the Wetting Condition and Amount of Containing Water

In the proposed method, we refer the wetting condition at the waterdrop collision point and determine the water splash model according to the wetting condition. In order to realize this, we subdivide the object's surface into cells and employ a method to manage material and information about wetting condition at each cell as mentioned in section 3.1.2. We generate a water splash which considers both the material of the surface and the wetting condition changing with time lapse based on this system.

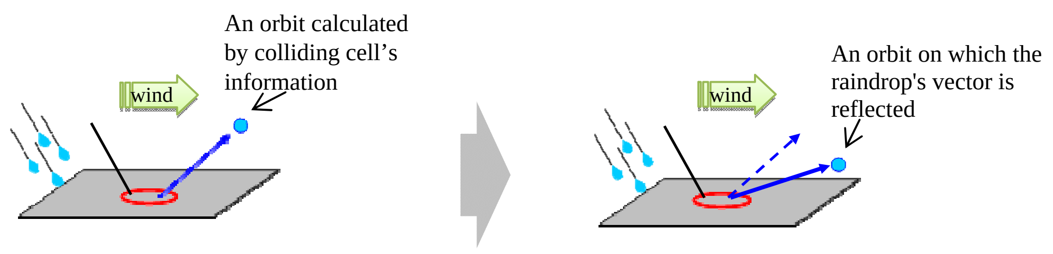
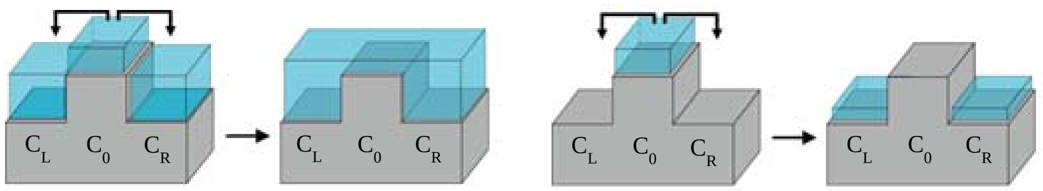


Figure 6. Change of the shape of a water splash reflecting the falling trajectory of a raindrop



(a) Case of $H_0 = H_R, H_L$

(b) Case of $H_0 > H_R, H_L$

Figure 7. Distribution of the water contained in a raindrop

Here we discuss about the change of the wetting condition on the object's surface which is caused by the time lapse in the rainy weather. If a waterdrop hits at a cell whose wetting condition is "dry", not a water splash but a dark spot is appeared on it because water soaks into cell's surface. Then some raindrops hit the cell, no more water is able to soak into the cell. In other words, the cell is saturated. The wetting condition of such saturated cell changes to "wet". If more raindrops hit the "wet" situation cell, some portion of water brought by each raindrop moves to neighboring cells. Figure 7 depicts a characteristic example of the situation through simplifying to one dimension. The height of water surface of each cell, H_n, is given by adding the depth of water to the original height of the cell. If we call the raindrop hit cell as C_0, the proposed method moves water to four neighboring cells to reduce difference among height of the water surface of cells through comparing the height of water surface of the C_0, H_0, with those of neighboring cells. Figure 7(a) shows a case that the height of the water surfaces of C_0 is equal to those of neighboring cells C_L and C_R. The height of water surfaces of C_L and C_R is expressed as H_L and H_R, respectively. In this case, one third of the water which the hit raindrop contains is accumulated to the total water amount of each cell. Figure 7(b) shows a case that H_0 is higher than H_L and H_R. In this case, the distributing water amount is decided in the following procedures.

(1) D_h, the increment of the height of water surface due to half amount of water of a hit raindrop (W_h), is calculated.

(2) If H_0 is higher than $\max(H_L+D_h, H_R+D_h)$, W_h is accumulated to the total water amount at C_L and C_R, respectively.

(3) If H_0 is lower than $\max(H_L+D_h, H_R+D_h)$, water contained in the raindrop is distributed to each cell. The distribution is carried out to make the heights of the water surfaces of cells equal.

Therefore, it will be in the state where a puddle occurs partially, and the cell's parameter will become one of the "wet", the "puddle (3 mm)", the "puddle (5 mm)", or the "puddle (10 mm)".

4.6.2 Reflection of Cell's Water Amount to the Water Splash

In every water splash model, firstly we obtain the information of cell which includes the colliding point, and then we select the water splash model by using the information. According to selected model, we decide the parameters which are used to draw the water splash such as the number of waterdrops for scattering, the initial velocity, and the shooting-out angle. Thus, we enable generation of the water splash corresponding to the change of the wetting condition caused by the temporal and/or the spatial (material and height of a cell) factors. Especially as for a scattering water splash model, the scale of a water splash changes with the wetting condition at the colliding cell. Table 1 summarizes a relationship between the wetting condition at a colliding cell and the corresponding water splash model. Figure 8 shows the relationship between the time lapse in the rainy weather and the change of rendered water splash. This figure explains the following; the moister a cell becomes, the greater a water splash's parameter value (the number of scattering waterdrop, initial velocity, and the degree of angle of shooting-out) becomes and finally the shape of the water splash becomes the crown-cone model. Table 1 also shows the distribution of the scattering model's parameter (the number of scattering waterdrop, initial velocity, and the degree of angle of shooting-out). These values are based on the numerical value acquired from the result of the experiment carried out shown in section 2

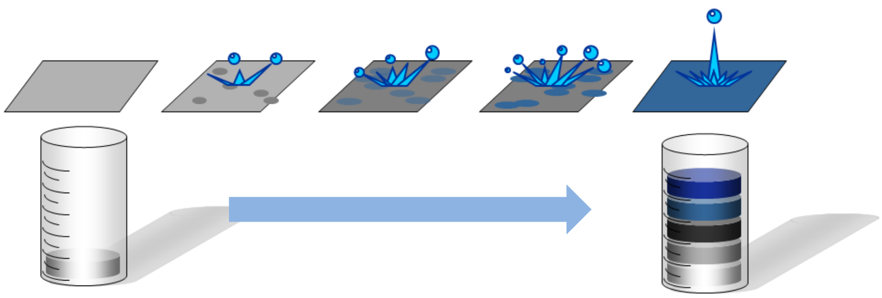
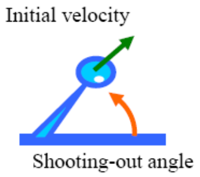
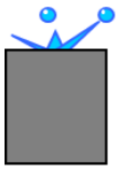
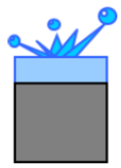
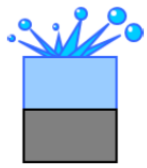


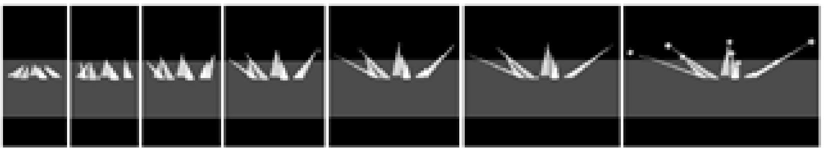
Figure 8. Relationship between the wetting condition and the water splash’s shape

Table 1. Relationship between wetting condition of a cell (asphalt) and water splash and the distribution of the scattering model's parameter

Wetting Condition	Wet	Puddle		
		Water depth: 3mm	Water depth: 5mm	Water depth: 10mm
Water splash	Scattering	Scattering	Scattering	Crown cone
Number of waterdrops	1~5	4~14	12~22	1
Shooting-out angle(deg)	1~30	1~60	1~90	90
Initial velocity(m/s)	0.1~1.0	0.15~1.5	0.2~2.0	0.1~2.0
				

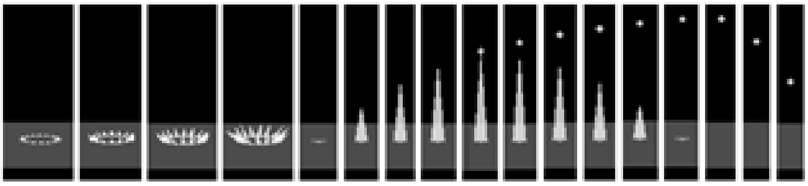
5. EXAMPLES

Figure 9 (a) and (b) show image sequences of two models (scattering and crown-cone) of the water splash. Figure 10 (a) shows a landscape including water splashes only, while Figure 10 (b) shows the same scene with the trajectories of the falling raindrops. Table 2 shows the drawing performance of the scattering model and the crown-cone model in the proposed method. We indicated the average of the 10 times result of measurement in which we generate water splashes at random. We consider that the number of water splashes to draw and the fps value are mostly in inverse proportion.



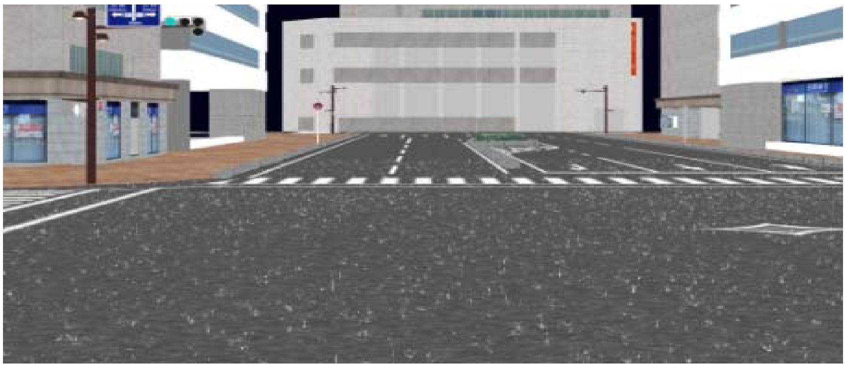
(a)Image sequence of a water splash of the scattering model

Figure 9. Example of image sequence of water splashes being through the proposed method generated

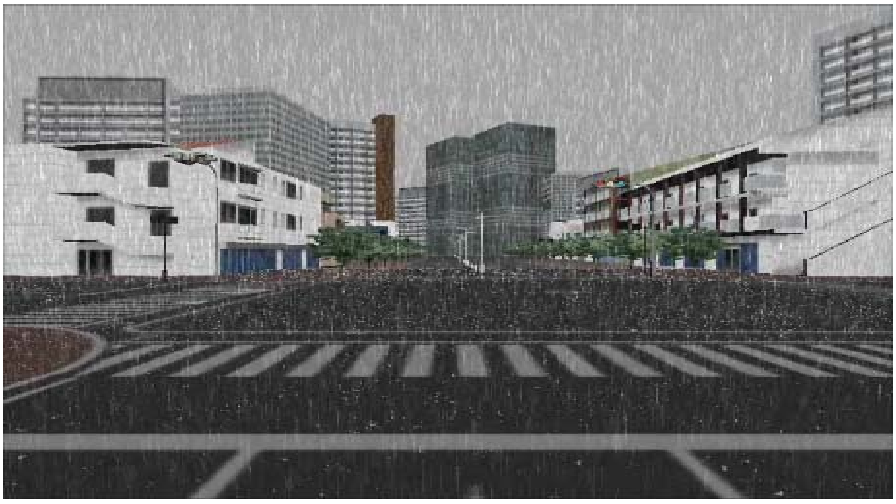


(b)Image sequence of a water splash of the crown-cone model

Figure 9. Example of image sequence of water splashes being through the proposed method generated (continued)



(a) A rainy landscape including water splashes only



(b) A rainy landscape including both water splashes and trajectories of raindrops

Figure 10. Examples

Table 2. Drawing performance (fps) under each conditions

The number of the water splash in a scene	Scattering model			Crown-cone model
	Wet	Puddle 3 mm	Puddle 5 mm	
100	492.61	303.03	204.08	534.73
500	165.84	81.90	52.00	222.22
1,000	85.11	43.71	23.30	124.38
3,000	30.36	14.96	9.05	45.35

(CPU: Intel Core 2 Quad 2.4 GHz, RAM: 2 GB, GPU: NVIDIA GeForce 8800GTS)

6. CONCLUSION

In this paper we proposed a simple method for rendering water splash. The proposed method consists of the novel three types of the models of water splash which were obtained based on experiments. Concretely, the proposed method has the following two features; (1) It allows us to reduce calculation cost for rendering the water splash through constructing from set of simple geometry. (2) It allows us to avoid a uniform and unnatural expression of the water splash through considering the difference at the colliding position of the waterdrop, such as the wetting condition, material, and height. We think that we realized low-cost and high-visual-effect expression of the water splash.

Future work includes expression of a ripple which is synchronized with the generation of water splash in a puddle.

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