



UTM

UNIVERSITI TEKNOLOGI MALAYSIA



"towards the endemic phase of COVID-19"

Mathematics for computer graphics project

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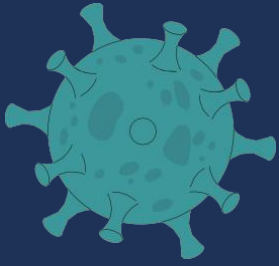


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2D Transformation and Interpolation in the project

Two types of interpolation, linear interpolation and trigonometric interpolation are used in this project. The angle degrees are increased in a linear way. Most of the interpolation used are the trigonometric interpolation.. Different angle degrees were used for different interpolation that were applied in different motion on different objects so that they could perform the motion simultaneously or at different time. Most of the transformation will be implemented together with trigonometric interpolation, while the linear interpolation will be only used for rotation transformation.

1.)2D Graphic Shape: Virus

There are two parts on Virus which are nucleus and particles which surround the nucleus. Both different parts have different motion which are realized by the transformations and the interpolations.

Nucleus

Motion & Animation	Transformation Used	Interpolation
Movement	Translation: <ul style="list-style-type: none">● To translate the center point of the nucleus to new positions in different angle degrees	<ul style="list-style-type: none">● To determine a sequence of new position which is in the range between the final destination and the starting point● Since the angle degree is changing in every frame, the new position will not be the same● When the angle degree is increasing in the range of 0 to 90 , the new positions determined will be more close to the final destination● Meanwhile, the center point of the nucleus will travel to these new positions in every frame● This will produce a motion that looked like the center of the nucleus is moving from starting point to final destination● Until the center of the nucleus reaches the final destination, the degree of interpolation will be limited to 90 degrees● It could prevent the nucleus from moving back to its starting point

	<p>How do you apply 2D transformation and interpolation</p> <ol style="list-style-type: none"> 1. Determine the coordinate of the final destination 2. Calculate the distance between the final destination and the starting point 3. Forming an interpolation formula with the distance between the final destination and the starting point to produce a sequence of values in the interval between the starting point and final destination according to the current angle degree. 4. Define the translation with the value which is calculated from the interpolation formula by using 3x3 homogeneous matrix 5. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which is the homogeneous coordinate of the starting point to get a new homogeneous coordinate which indicate the new position of the center of the nucleus 6. Since the angle degrees is changing in every frame, the homogeneous matrix of the translation will not be constant 7. Hence, the homogeneous coordinate of the new position will change in a way that has been described in the above interpolation section before
Zoom out	<p>Scaling</p> <ul style="list-style-type: none"> ● To alter the length of the radius of the nucleus to a new length in different angle degrees ● Scale factor below than 1 and higher than 0 is used to shrink the radius of the nucleus to achieve the purpose of zooming out the nucleus <ul style="list-style-type: none"> ● two scale factors will be used in the interpolation formula. ● One is used as a final scale factor while another one is used as original scale factor which is considered as 1 ● The interpolation formula is used to determine a sequence of new scale factor in the range between the original scale factor and the final scale factor ● Since the angle is changing in every frame, the new scale factor will not be the same ● When the angle degree is increasing in the range of 0 to 90, the scale factor will be more close to the value of the final scale factor ● Meanwhile, the radius of the nucleus will be scaled these new factor in every frame ● This will produce a variation in size of the

		<p>nucleus from its original size to its final size slowly</p> <ul style="list-style-type: none"> ● Until the scale factor from the interpolation formula reaches the final scale factor, the degree of interpolation will be limited to 90 degrees ● It could prevent the nucleus from returning back to its original size
	<ol style="list-style-type: none"> 1. Determine the value of the final scale factor 2. Forming an interpolation formula to produce a sequence of scale factor in the interval between the starting scale factor and final scale factor according to the current angle degree 3. Define the scaling with the value which is calculated from the interpolation formula by using 2x2 homogeneous matrix 4. The scaling homogeneous matrix will be multiplied with another 2x1 homogeneous matrix which is the homogeneous coordinate of the radius to get a new homogeneous coordinate which indicate the new radius of the nucleus 5. Since the angle degree is changing in every frame, the homogeneous matrix of the scaling will not be constant 6. Hence, the homogeneous coordinate of the new radius will change in a way that has been described in the above interpolation section until it reaches its final length 	

Particle

Motion & Animation	Transformation Used	Interpolation
Rotation around the nucleus	<p>Rotation:</p> <ul style="list-style-type: none"> ● To rotate the center point of the particle along a circular path at the center of the nucleus <p>Scaling</p> <ul style="list-style-type: none"> ● To adjust the radius of the rotation at the center of the nucleus so that a realistic path of rotation around the nucleus could be realized <p>Translation</p> <ul style="list-style-type: none"> ● To move the pivot point of the rotation to the center of nucleus 	<ul style="list-style-type: none"> ● Linear interpolation is used in rotation transformation ● To determine a sequence of new positions in a circle path of rotation at different angle degrees. ● When the angle degree is increasing, the center point of the particles will move in a circle path ● There is no limit on the angle degree so that the the particles could move in circle in one direction only ● Trigonometric interpolation is used in scaling transformation ● If we used rotation only , the particles will only move around the perimeter of the circle. ● Hence scaling transformation with scaling factor that is lower than 1 and higher than 0 is applied to decrease the radius of the rotation when the particles are getting closer to the center point of the nucleus ● It could produce a realistic rotation path around a center point of the nucleus. ● The angle degree is limited at 180 degrees so that the radius could achieve its maximum or original value when the it is at 0 degree and 180 degree and achieve its minimum at 90 degree

	<p>How do you apply 2D transformation and interpolation</p> <p>The sequence of transformation: Rotation => Scaling => Transformation</p> <p>Rotation</p> <ol style="list-style-type: none"> 1. Define the rotation by using 3x3 homogeneous matrix 2. Define a 3x1 homogeneous matrix which is {0,0,1} as a pivot point which is centered at origin <p>Scaling</p> <ol style="list-style-type: none"> 1. Determine the value of the scale factor or the peak when the angle degree achieve 90 2. Forming an interpolation formula to produce a sequence of scale factor in the interval between the starting scale factor and its peak according to the current angle degree 3. Define the scaling with the value which is calculated from the interpolation formula by using 3x3 homogeneous matrix 4. The scaling homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which is the homogeneous coordinate that we get from rotation transformation. 5. The homogeneous coordinate will be scaled in a way that has been mentioned in the above interpolation section <p>Translation</p> <ol style="list-style-type: none"> 1. Define the translation with the homogeneous coordinate of the center of the nucleus by using 3x3 homogeneous matrix 2. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which we get from the scaling transformation 3. The center point of rotation will be centered at the center of the nucleus 	
Zoom out	<p>Scaling</p> <ul style="list-style-type: none"> ● To alter the length of the radius of the nucleus to a new length in different angle degrees ● Scale factor below than 1 and higher than 0 is used to shrink the radius of the nucleus to achieve the purpose of zooming out the particles 	<ul style="list-style-type: none"> ● two scale factors will be used in the interpolation formula. ● One is used as a final scale factor while another one is used as original scale factor which is considered as 1 ● The interpolation formula is used to determine a sequence of new scale factor in the range between the original scale factor and the final scale factor ● Since the angle is changing in every frame, the new scale factor will

		<p>not be the same</p> <ul style="list-style-type: none"> ● When the angle degree is increasing in the range of 0 to 90, the scale factor will be more close to the value of the final scale factor ● Meanwhile, the radius of the particles will be scaled by these new factor in every frame ● This will produce a variation in size of the particles from its original size to its final size slowly ● Until the scale factor from the interpolation formula reaches the final scale factor, the degree of interpolation will be limited to 90 degrees ● It could prevent the nucleus from returning back to its original size
	<ol style="list-style-type: none"> 1. Determine the value of the final scale factor 2. Forming an interpolation formula to produce a sequence of scale factor in the interval between the starting scale factor and final scale factor according to the current angle degree 3. Define the scaling with the value which is calculated from the interpolation formula by using 2x2 homogeneous matrix 4. The scaling homogeneous matrix will be multiplied with another 2x1 homogeneous matrix which is the homogeneous coordinate of the radius to get a new homogeneous coordinate which indicate the new radius of the particles 5. Since the angle degree is changing in every frame, the homogeneous matrix of the scaling will not be constant 6. Hence, the homogeneous coordinate of the new radius will change in a way that has been described in the above interpolation section until it reaches its final length 	
Falling off from the nucleus	<p>Rotation:</p> <ul style="list-style-type: none"> ● To rotate the center point of the particle along a circular path at a pivot point which is below the center of the nucleus to realize the motion 	<ul style="list-style-type: none"> ● Linear interpolation is used in rotation transformation ● To determine a sequence of new positions in a circle path of rotation at different angle degrees. ● There are two particles that will fall off from the

		<p>nucleus in both direction which is clockwise and anticlockwise</p> <ul style="list-style-type: none"> ● For clockwise direction, the angle degree will be increased ● While for anticlockwise direction, the angle degree will be decreased ● The limits are recommended to be set in the range of 0-90 degrees and in the range of -90-0 degrees for clockwise direction and anticlockwise direction respectively to realize the path of falling off ● When the angle degree achieves the limit, the change will be stopped to avoid any change to the current position of the particles
	<p>Translation</p> <ul style="list-style-type: none"> ● To move the pivot point of the rotation to the point below the center of the nucleus 	
	<p>The sequence of transformation: Rotation => Transformation</p> <p>Rotation</p> <ol style="list-style-type: none"> 1. Determine the limit for the rotation of the particle 2. Setting a condition for the rotation so that it could only be realized before the angle degree achieves the limit 3. Define the rotation by using 3x3 homogeneous matrix 4. Define a 3x1 homogeneous matrix which is {0,0,1} as a pivot point which is centered at origin <p>Translation</p> <ol style="list-style-type: none"> 1. Determine the coordinate of the pivot point that is below the center point of the nucleus 2. Define the translation with the homogeneous coordinate of the pivot point by using 3x3 homogeneous matrix 3. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which we get from the rotation transformation 4. The center point of rotation will be centered at the pivot point 	

2.)2D Graphic Shape: Map

The map is formed by a bunch of lines. Transformation and interpolation are applied in these lines.

Motion & Animation	Transformation Used	Interpolation
Displaying or Drawing	Translation: <ul style="list-style-type: none"> ● To translate the endpoint to new positions in different angle degrees until it reaches its final destination 	<ul style="list-style-type: none"> ● To determine a sequence of new position which is in the range between the final destination and the starting point ● Since the angle degree is changing in every frame, the new position will not be the same ● When the angle degree is increasing in the range of 0 to 90 , the new positions determined will be more close to the final destination ● Meanwhile, the endpoint of the nucleus will travel to these new positions in every frame ● This will produce a motion that looked like the line is drawn from starting point to its final destination ● Until the endpoint of the nucleus reaches the final destination, the degree of interpolation will be limited to 90 degrees ● It could prevent the nucleus from moving back to its starting point
	How do you apply 2D transformation and interpolation	
	<ol style="list-style-type: none"> 1. Determine the coordinate of the final destination of the line 2. Calculate the distance between the final destination and the starting point 3. Forming an interpolation formula with the distance between the final destination and the starting point to produce a sequence of values in the interval between the starting point and final destination according to the current angle degree. 4. Define the translation with the value which is calculated from the interpolation formula by using 3x3 	

	<p>homogeneous matrix</p> <ol style="list-style-type: none"> 5. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which is the homogeneous coordinate of the starting point to get a new homogeneous coordinate which indicate the new position of the center of the nucleus 6. Since the angle degrees is changing in every frame, the homogeneous matrix of the translation will not be constant 7. Hence, the homogeneous coordinate of the new position will change in a way that has been described in the above interpolation section before
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3.)2D Graphic Shape: Infected Area

Infected Area are formed by using a combination of different layers of circles of different colors which are red, white and black to produce some animation or motion. Several circles of infected areas are used for showing the spreading animation. These circles are generated at random point in a range of certain coordinates

Motion & Animation	Transformation Used	Interpolation
Enlarge	<p>Scaling</p> <ul style="list-style-type: none"> ● To alter the length of the radius of the infected area to a new length in different angle degrees ● Scale factor higher than 1 is used to enlarge the radius of the infected area 	<ul style="list-style-type: none"> ● two scale factor will be used in the interpolation formula. ● One is used as a final scale factor while another one is used as original scale factor which is considered as 1 ● The interpolation formula is used to determine a sequence of new scale factor in the range between the original scale factor and the final scale factor ● Since the angle is changing in every frame, the new scale factor will not be the same ● When the angle degree is increasing in the range of 0 to 90, the scale factor will be more close to the value of the final scale factor ● Meanwhile, the

		<p>radius of the nucleus will be scaled by these new factor in every frame</p> <ul style="list-style-type: none"> ● This will produce a variation in size of the infected area from its original size to its final size slowly ● Until the scale factor from the interpolation formula reaches the final scale factor, the degree of interpolation will be limited to 90 degrees ● It could prevent the nucleus from returning back to its original size <p>Extra: three layer of circle with different colors will be interpolated with different rate of change of angle degrees so that the animation of wave spreading could be realized</p>
	How do you apply 2D transformation and interpolation	
	<ol style="list-style-type: none"> 1. Determine the value of the final scale factor 2. Forming an interpolation formula to produce a sequence of scale factor in the interval between the starting scale factor and final scale factor according to the current angle degree 3. Define the scaling with the value which is calculated from the interpolation formula by using 2x2 homogeneous matrix 4. The scaling homogeneous matrix will be multiplied with another 2x1 homogeneous matrix which is the homogeneous coordinate of the radius to get a new homogeneous coordinate which indicate the new radius of the infected area 5. Since the angle degree is changing in every frame, the homogeneous matrix of the scaling will not be constant 6. Hence, the homogeneous coordinate of the new radius will change in a way that has been described in the above interpolation section until it reaches its final length 	

Spreading	<p>Translation:</p> <ul style="list-style-type: none"> ● To translate the randomly generated center point of the infected areas downward from its original y-coordinate to achieve the purpose of showing animation of spreading 	<ul style="list-style-type: none"> ● To determine a sequence of new position which is in the range between the final destination and the starting point ● Since the angle degree is changing in every frame, the new position will not be the same ● Meanwhile, the center point of the nucleus will travel to these new positions in every frame ● There is no limit in the variation of the angle degree so that the infected area could be spread in the range from the starting point to the final destination repeatedly ● This will produce an animation that looked like the infected area is spreading from starting point to final destination
	<ol style="list-style-type: none"> 1. Determine the coordinate of the final destination 2. Calculate the distance between the final destination and the starting point 3. Forming an interpolation formula with the distance between the final destination and the starting point to produce a sequence of values in the interval between the starting point and final destination according to the current angle degree. 4. Define the translation with the value which is calculated from the interpolation formula by using 3x3 homogeneous matrix 5. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which is the homogeneous coordinate of the starting point to get a new homogeneous coordinate which indicate the new position of the center of the nucleus 6. Since the angle degrees is changing in every frame, the homogeneous matrix of the translation will not be constant 7. Hence, the homogeneous coordinate of the new position will change in a way that has been described in the above interpolation section before 	

4.)2D Graphic Shape: Syringe

The syringe is built by using the combination of rectangles of different sizes and color. The coordinates of the upper left vertex and bottom right vertex of these rectangles are taking the center point of the middle part of the syringe. Hence the transformation and interpolation will be only applied to the center point of the middle part of the syringe. Then, all the rectangles will also make corresponding transformation and interpolation.

Motion & Animation	Transformation Used	Interpolation
Movement	<p>Translation:</p> <ul style="list-style-type: none">● To translate the center point of the middle part of the syringe to new positions in different angle degrees	<ul style="list-style-type: none">● To determine a sequence of new position which is in the range between the final destination and the starting point● Since the angle degree is changing in every frame, the new position will not be the same● When the angle degree is increasing in the range of 0 to 90 , the new positions determined will be more close to the final destination● Meanwhile, the center point of the middle part of the syringe will travel to these new positions in every frame● This will produce a motion that looked like the syringe is moving from starting point to final destination● Until the center point of the syringe reaches the final destination, the degree of interpolation will be limited to 90 degrees● It could prevent the syringe from moving back to its starting point

	How do you apply 2D transformation and interpolation
	<ol style="list-style-type: none"> 1. Determine the coordinate of the final destination 2. Calculate the distance between the final destination and the starting point 3. Forming an interpolation formula with the distance between the final destination and the starting point to produce a sequence of values in the interval between the starting point and final destination according to the current angle degree. 4. Define the translation with the value which is calculated from the interpolation formula by using 3x3 homogeneous matrix 5. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which is the homogeneous coordinate of the starting point to get a new homogeneous coordinate which indicate the new position of the center of the nucleus 6. Since the angle degrees is changing in every frame, the homogeneous matrix of the translation will not be constant 7. Hence, the homogeneous coordinate of the new position will change in a way that has been described in the above interpolation section before

5.)2D Graphic Shape: Clock

The clock is composed of circles with different colors and two lines of different length to be considered as hour hand and minute hand. The starting point of both of these lines is centered at the center point of the clock, or in other way, the circles of the clock. These components have different motion or animation which could be realized by the transformations and the interpolations.

Motion & Animation	Transformation Used	Interpolation
Rotation of hour hand and minute hand	Rotation: <ul style="list-style-type: none"> ● To rotate the ending point of the hour hand and minute hand along a circular path at center point of the clock 	<ul style="list-style-type: none"> ● Linear interpolation is used in rotation transformation ● To determine a sequence of new position in a circle path of rotation at different angle degrees. ● There is no limit for the rotation so that the hands could rotate in a complete circle repeatedly <p>Extra: Both of these hand will be interpolated with different rate of change of angle degrees to show that the time is passing in a fast way obviously</p>

	Translation <ul style="list-style-type: none"> ● To move the pivot point of the rotation to the center point of the clock 	
	How do you apply 2D transformation and interpolation	
	The sequence of transformation: Rotation => Transformation Rotation <ol style="list-style-type: none"> 1. Define the rotation by using 3x3 homogeneous matrix 2. Define a 3x1 homogeneous matrix which is {0,0,1} as a pivot point which is centered at origin Translation <ol style="list-style-type: none"> 1. Define the translation with the homogeneous coordinate of the center point of the clock by using 3x3 homogeneous matrix 2. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which we get from the rotation transformation 3. The center point of rotation will be located at the center point of the clock 	
Movement	Translation: <ul style="list-style-type: none"> ● To translate the center point of the clock to new positions in different angle degrees 	<ul style="list-style-type: none"> ● To determine a sequence of new position which is in the range between the final destination and the starting point ● Since the angle degree is changing in every frame, the new position will not be the same ● When the angle degree is increasing in the range of 0 to 90 , the new positions determined will be more close to the final destination ● Meanwhile, the center point of the clock will travel to these new positions in every frame ● This will produce a motion that looked like the clock is moving from starting point to final destination ● Until the center point of the clock reaches the final destination, the degree of interpolation will be limited to 90 degrees ● It could prevent the clock

		<p>from moving back to its starting point</p> <ul style="list-style-type: none"> ● The above limit mentioned is used for the translation of first time ● While, for translation of second time, there is a condition to enable the interpolation keep looping in a range of degrees by changing the direction of variation of angle degree ● After the angle degree pass over 90 degrees and it achieve a certain angle, the angle degree will be decreased ● After that, when the angle degree achieve 90 degrees again, the angle degree will be increased again ● This loop of variation of angle degree will causes a repeated small zoom in and zoom out animation of the clock circles ●
Zoom out and Zoom in	<p>Scaling</p> <ul style="list-style-type: none"> ● To alter the length of the radius of the the clock circle and hands to a new length in different angle degrees ● Scale factor below than 1 and higher than 0 is used to shrink the radius of the nucleus to achieve the purpose of zooming out the clock ● Scale factor higher than 1 is used to enlarge the radius of the nucleus to achieve the purpose of zooming out the clock 	<ul style="list-style-type: none"> ● two scale factors will be used in the interpolation formula. ● One is used as a final scale factor while another one is used as original scale factor which is considered as 1 ● The interpolation formula is used to determine a sequence of new scale factor in the range between the original scale factor and the final scale factor ● Since the angle is changing in every frame, the new scale factor will not be the same ● When the angle degree is increasing in the range of 0 to 90, the scale factor will be more close to the value of the final scale factor ● Meanwhile, the radius of

		<p>the clock circles will be scaled by these new factor in every frame</p> <ul style="list-style-type: none"> ● This will produce a variation in size of the particles from its original size to its final size slowly ● Until the scale factor from the interpolation formula reaches the final scale factor, the degree of interpolation will be limited to 90 degrees ● It could prevent the clock from returning back to its original size ● While, for translation of second time, there is a condition to enable the interpolation keep looping in a range of degrees by changing the direction of variation of angle degree ● After the angle degree pass over 90 degrees and it achieve a certain angle, the angle degree will be decreased ● After that, when the angle degree achieve 90 degrees again, the angle degree will be increased again ● This loop of variation of angle degree will causes a repeated small zoom in and zoom out animation of the clock circles <p>Extra:</p> <ul style="list-style-type: none"> ● The clock circles will be interpolated with different rate of change of angle degrees to realize a special animation of zooming in and spatial transformation
	<ol style="list-style-type: none"> 1. Determine the value of the final scale factor 2. Forming an interpolation formula to produce a sequence of scale factor in the interval between the starting scale factor and final scale factor according to the current angle degree 3. Define the scaling with the value which is calculated from the 	

	<p>interpolation formula by using 2x2 homogeneous matrix</p> <ol style="list-style-type: none"> 4. The scaling homogeneous matrix will be multiplied with another 2x1 homogeneous matrix which is the homogeneous coordinate of the radius to get a new homogeneous coordinate which indicate the new radius of the clock components 5. Since the angle degree is changing in every frame, the homogeneous matrix of the scaling will not be constant 6. Hence, the homogeneous coordinate of the new radius will change in a way that has been described in the above interpolation section until it reaches its final length
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6.)2D Graphic Shape: Road

The road is represented by a rectangle with black color. The length of the rectangle could be adjusted by applying the transformation and the interpolation

Motion & Animation	Transformation Used	Interpolation
Expand	<p>Translation:</p> <ul style="list-style-type: none"> ● To translate the left upper vertex of the rectangle to new positions in different angle degrees 	<ul style="list-style-type: none"> ● To determine a sequence of new position which is in the range between the final destination and the starting point ● Since the angle degree is changing in every frame, the new position will not be the same ● When the angle degree is increasing in the range of 0 to 90 , the new positions determined will be more close to the final destination ● Meanwhile, the left upper vertex of the rectangle will travel to these new positions in every frame ● This will produce a motion that looked like the road is expanding from starting point to final destination ● Until the left upper vertex of the rectangle reaches the final destination, the degree of interpolation will be limited to 90 degrees ● It could prevent the road from shrink back to its starting point

	How do you apply 2D transformation and interpolation
	<ol style="list-style-type: none"> 1. Determine the coordinate of the final destination 2. Calculate the distance between the final destination and the starting point 3. Forming an interpolation formula with the distance between the final destination and the starting point to produce a sequence of values in the interval between the starting point and final destination according to the current angle degree. 4. Define the translation with the value which is calculated from the interpolation formula by using 3x3 homogeneous matrix 5. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which is the homogeneous coordinate of the starting point to get a new homogeneous coordinate which indicate the new position of the center of the nucleus 6. Since the angle degrees is changing in every frame, the homogeneous matrix of the translation will not be constant 7. Hence, the homogeneous coordinate of the new position will change in a way that has been described in the above interpolation section before

7.)2D Graphic Shape: Reflection Line

A line which is drawn from the top side of the window to the bottom side of the window represents a borderline to divide the scene into “past” and “present” so that the difference between the pandemic phase and endemic phase could be seen. This line has been applying the transformation and the interpolation to perform animation

Motion & Animation	Transformation Used	Interpolation
Movement	<p>Translation:</p> <ul style="list-style-type: none">● To translate the both of the coordinates of the reflection line to new positions in different angle degrees	<ul style="list-style-type: none">● To determine a sequence of new position which is in the range between the final destination and the starting point● Since the angle degree is changing in every frame, the new position will not be the same● When the angle degree is increasing in the range of 0 to 90 , the new positions determined will be more close to the final destination● Meanwhile, both of the coordinates of the reflection line will travel to these new positions in every frame● This will produce a motion that looked like the reflection line is moving from starting point to final destination● Until both coordinate of the reflection line reaches the final destination, the degree of interpolation will be limited to 90 degrees● It could prevent the reflection line from returning back to its starting point

	How do you apply 2D transformation and interpolation
	<ol style="list-style-type: none"> 1. Determine the coordinate of the final destination 2. Calculate the distance between the final destination and the starting point 3. Forming an interpolation formula with the distance between the final destination and the starting point to produce a sequence of values in the interval between the starting point and final destination according to the current angle degree. 4. Define the translation with the value which is calculated from the interpolation formula by using 3x3 homogeneous matrix 5. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which is the homogeneous coordinate of the starting point to get a new homogeneous coordinate which indicate the new position of the upper left vertex of the rectangle 6. Since the angle degrees is changing in every frame, the homogeneous matrix of the translation will not be constant 7. Hence, the homogeneous coordinate of the new position will change in a way that has been described in the above interpolation section before

8.)2D Graphic Shape: Pedestrian

Pedestrian composed a circle which represents the head, several lines which represent body and legs. There are two kind of pedestrian. One performs animations in the side of the past while another one performs animations in the side of the present. Since the pedestrian is not like the syringe to have a point as a reference point for the components, the transformations and interpolation will be applied to every components of the pedestrian so that they could perform motion or animation simultaneously

Present Side

Motion & Animation	Transformation Used	Interpolation
Movement	<p>Translation:</p> <ul style="list-style-type: none"> ● To translate pedestrian to new positions in different angle degrees ● The starting point will be the current point of the reflection line 	<ul style="list-style-type: none"> ● To determine a sequence of new position which is in the range between the final destination and the starting point ● Since the angle degree is changing in every frame, the new position will not be the same ● When the angle degree is increasing in the range of 0 to 90 , the new positions determined will be more close to the final destination ● Meanwhile, the center point of the head and the coordinates of other lines will travel to these new positions in every frame ● This will produce a motion that looked like the reflection line is moving from starting point to final destination ● Until the pedestrian reaches the final destination, the degree of interpolation will be 90 degrees ● Then, the angle degree will be returning back to 0 degrees again so that the pedestrian could walk from starting point repeatedly to the final destination <p>Extra:</p> <ul style="list-style-type: none"> ● When the pedestrian pass over the boundary of the window, the starting point will be updated to the current position of the reflection line, and the angle will be return back to 0 so that the pedestrian could be spawn from the reflection line

	How do you apply 2D transformation and interpolation	
	<ol style="list-style-type: none"> 1. Determine the distance of translation 2. Forming an interpolation formula with the distance of translation to produce a sequence of values in the interval between the starting point and final destination according to the current angle degree. 3. Define the translation with the value which is calculated from the interpolation formula by using 3x3 homogeneous matrix 4. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which is the homogeneous coordinate of the starting point to get a new homogeneous coordinate which indicate the new position of the upper left vertex of the rectangle 5. Since the angle degrees is changing in every frame, the homogeneous matrix of the translation will not be constant 6. Hence, the homogeneous coordinate of the new position will change in a way that has been described in the above interpolation section before 	
Swinging legs during the movement	<p>Translation:</p> <ul style="list-style-type: none"> ● For this animation, there are two types of translation will be used for different purpose ● One is for performing leg swinging during the movement ● While another one is for moving the pivot point from the origin to the starting point of the line which represents legs after reflection ● As a result, both of the legs will be swinging with the movement of the pedestrian 	<ul style="list-style-type: none"> ● To determine a sequence of new position which is in the range between the final destination and the starting point ● Since the angle degree is changing in every frame, the new position will not be the same ● There is no limit for the angle degree variation. ● This means that the angle will go through every 360 degrees ● The trigonometric interpolation formula used in this animation could produce negative and positive variation ● In the variation of degrees from 0 to 90 and from 270 to 360, the variation of translation will be positive ● The final position will be positive in the range from 0 degrees to 180 degrees ● The distance of leg swinging will achieve positive peak when the angle degree achieves 90 degrees ● In the range of degrees from 90 to 270, the variation of translation will be negative ● The final position will be negative in the range from 180 degrees to 360 degrees ● The distance of leg swinging will achieve negative peak when the angle degree achieves 90 degrees ● the endpoint of the leg will travel to these generated new positions in every frame ● This will produce a motion that the

	<p>Reflection:</p> <ul style="list-style-type: none"> ● To reflect the translation which is mentioned above for the leg swinging relative to the y-axis to change the direction of the translation 	<p>leg is swinging with a certain distance when the pedestrian is walking</p>
	<p>Sequence of transformation Translation=> Composition of Reflection and Translation)</p> <p>Translation</p> <ol style="list-style-type: none"> 1. Determine the distance of translation for leg swinging 2. Forming an interpolation formula with the distance of translation to produce a sequence of values in the interval between the starting point of endpoint of the leg and final destination according to the current angle degree. 3. Define the translation with the value which is calculated from the interpolation formula by using 3x3 homogeneous matrix 4. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which is the homogeneous coordinate of the starting point to get a new homogeneous coordinate which indicate the new position of the endpoint of the leg 5. Since the angle degrees is changing in every frame, the homogeneous matrix of the translation will not be constant 6. Hence, the homogeneous coordinate of the new position will change in a way that has been described in the above interpolation section before <p>Composition of Reflection and Translation Sequence: Reflection => Translation</p> <p>Reflection</p> <ol style="list-style-type: none"> 1. Define a 3x1 homogeneous matrix which is {0,0,1) as a pivot point which is centered at origin 2. The translation homogeneous matrix from the above part will be used to multiply with the origin homogeneous matrix to get a new homogeneous coordinate which indicate the new positions from the origin 3. Define a 3x3 reflection homogeneous matrix that could cause reflection relative to y-axis 4. The reflection homogeneous matrix will be multiplied with the homogeneous coordinate from 3.) to get a new homogeneous coordinate that reverse the sign of the x-coordinate <p>Translation</p> <ol style="list-style-type: none"> 1. Define the translation with the homogeneous coordinate of the starting point of the endpoint of another leg by using 3x3 homogeneous matrix 2. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which we get from the reflection transformation 3. The pivot point will be centered at the starting point of the endpoint of the leg 	

Past Side

The animations or motions of pedestrians in the present side have been used for pedestrians in the pastside also. However, there is some change for the movement animation only so that the movement of pedestrians in the past side could be opposite to that in the present side.

Motion & Animation	Transformation Used	Interpolation
Movement	<p>Translation:</p> <ul style="list-style-type: none">● For this animation, there are two types of translation will be used for different purpose● One is for performing pedestrian movement● While another one is for moving the pivot point from the origin to the starting point that is the current coordinates of the reflection line	<ul style="list-style-type: none">● To determine a sequence of new position which is in the range between the final destination and the starting point● Since the angle degree is changing in every frame, the new position will not be the same● When the angle degree is increasing in the range of 0 to 90 , the new positions determined will be more close to the final destination● Meanwhile,the center point of the head and the coordinates of other lines will travel to these new positions in every frame● This will produce a motion that looked like the reflection line is moving from starting point to final destination● Until the pedestrian reaches the final destination, the degree of interpolation will be 90 degrees● However, it will be a bit different to the present side after the angle degrees achieve 90 degrees● It will be the same that the angle degree will be returning back to 0 degree , but the starting point will be the final destination of movement of pedestrian in present side rather than the current point of the reflection line● It could display a scene that two pedestrian passing each other in different direction in present side <p>Extra:</p> <ul style="list-style-type: none">● When the pedestrian pass over the boundary of the window, the starting point will be updated to the final destination of the movement of pedestrian in present side, and the angle will be return back to 0 so that the pedestrian could be spawn from there

	<p>Reflection:</p> <ul style="list-style-type: none"> ● To reflect the translation which is mentioned above for the movement relative to the y-axis to change the direction of the translation 	
	<p>Sequence of transformation Translation=> Composition of Reflection and Translation)</p> <p>Translation</p> <ol style="list-style-type: none"> 1. Determine the distance of translation for movement 2. Forming an interpolation formula with the distance of translation to produce a sequence of values in the interval between the starting point and final destination according to the current angle degree. 3. Define the translation with the value which is calculated from the interpolation formula by using 3x3 homogeneous matrix 4. Define a 3x1 homogeneous matrix which is the homogeneous coordinate of the origin, {0,0,0} 5. The translation homogeneous matrix will be multiplied with the homogeneous matrix of the origin to get a new homogeneous coordinate which indicate the new positions after the translation from the origin <p>Composition of Reflection and Translation Sequence: Reflection => Translation</p> <p>Reflection</p> <ol style="list-style-type: none"> 1. Define a 3x3 reflection homogeneous matrix that could cause reflection relative to y-axis 2. The reflection homogeneous matrix will be multiplied with the homogeneous coordinate from the above translation to get a new homogeneous coordinate that reverse the sign of the x-coordinate <p>Translation</p> <ol style="list-style-type: none"> 1. Define the translation with the homogeneous coordinate of the starting point of the above translation which is the current coordinate of reflection line by using 3x3 homogeneous matrix 2. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which we get from the reflection transformation 3. The pivot point will be centered at the points of reflection line 4. After the pedestrian passing over the boundary of window, the starting point of translation will be changed to the final destination of the movement of pedestrian in present side 	

9.)2D Graphic Shape: Mask

Mask 's design is composed of several lines and eclipse. The value of vertices are defined for assigning the endpoint and starting point of the lines. The area enclosed by the lines is white in color. The lines are connected by directly assigning the endpoint of neighboring lines or the starting point of neighboring lines as the starting point or endpoint of another line. Hence, a change in coordinate of a vertex may also cause some change to other vertices

Motion & Animation	Transformation Used	Interpolation
Wearing	<p>Shearing:</p> <ul style="list-style-type: none"> ● To shear the top middle vertex of the mask to positive y-direction ● To shear the bottom middle vertex of the mask to negative y-direction ● The shear factor is in the range that larger than 1 for positive shearing and smaller than 1 for negative shearing so that the middle point of top side and bottom side of the mask could move upward and downward respectively <p>Translation:</p> <ul style="list-style-type: none"> ● To translate the pivot point from origin to the neighbouring vertex of the middle vertex of the top and bottom of the mask 	<ul style="list-style-type: none"> ● two shear factors will be used in the interpolation formula. ● One is used as a final scale factor while another one is used as original scale factor which is considered as 0 ● The interpolation formula is used to determine a sequence of new shear factor in the range between the original shear factor and the final shear factor ● Since the angle is changing in every frame, the new shear factor will not be the same ● There is no limit in variation of angle degree. ● When the angle degree is increasing in the range of 0 to 90 and the range of 180 to 270 in every cycle of 360 degrees, the shear factor will be more close to the value of the final shear factor ● When the angle degree is increasing in the range of 90 to 180 and the range of 270 to 360 in every cycle of 360 degrees, the shear factor will be more closer to the value of the starting shear factor ● the vertex of top and bottom of the mask will be shear by these new factor in every frame ● This will produce a variation in y-coordinate of the middle vertices from its original position to its final position slowly ● Since there is no limit, the variation of the y-coordinate will be repeated ● With this, an animation of wearing mask and not wearing mask will be switched repeatedly

	How do you apply 2D transformation and interpolation
	<p>The sequence of transformation: Shearing => Transformation</p> <p>Shearing</p> <ol style="list-style-type: none"> 1. Define the shearing relative to y-axis by using 3x3 homogeneous matrix 2. Calculate the distance from the neighboring vertex to the middle point of top or bottom of the mask 3. Define a 3x1 homogeneous matrix with the distance that is calculated from 2.) 4. Multiply 3x1 homogeneous matrix with the 3x3 shearing homogeneous matrix to get new position of vertex from the origin <p>Translation</p> <ol style="list-style-type: none"> 1. Define the translation with the homogeneous coordinate of the neighboring vertex by using 3x3 homogeneous matrix 2. The translation homogeneous matrix will be multiplied with another 3x1 homogeneous matrix which we get from the shearing transformation 3. The center point of shearing will be located at the neighboring vertex

Contribution To This Project

Group Member	Responsibility & Contribution
Sondos Moustafa	<ul style="list-style-type: none"> ● Design the Project Document ● Project Testing
Tan Kai Yuan	<ul style="list-style-type: none"> ● Preparing an adjusted version of project for the case that the original version couldn't run ● Putting epilepsy warning in the code ● Project Testing
Yeo Chun Teck	<ul style="list-style-type: none"> ● Thinking of ideas about the animation and the theme ● Thinking of the design for implementation of transformation and interpolation ● Design the interaction between the transformation and interpolation ● Design the program for the project ● Writing the document for explaining the project ● Organizing and commenting the code ● Project demo video recording