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Modeling and Visualization of Artillery Fire Formation based on Target Coordinates in The Forward Observer Simulator

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ABSTRACT

The Forward Observer (FO) role is vital in military operations, especially in the Medan Artillery unit. FO was in charge of directing artillery fire against the target. In the execution of artillery fire, several types of artillery fire formations are often carried out to hit the target correctly. The formation includes Tama, Tamu, Seka, Seki and Lingkar. In the FO simulator, the artillery fire formation is modeled and visualized in 3D. Modeling and visualization of artillery fire formation can save costs for military operations training in the Medan Artillery unit. In the test results, by entering several parameters, the formula has succeeded in modeling the type of artillery fire according to the type of formation.

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1. Introduction

The Forward Observer (FO) in military operations is essential. FO was responsible for directing artillery fire at the target. Artillery is an indirect firearm system located far from the target or outside the line of sight of their target [1]. FO serves as the point of the weapon, sending the target's location and making corrections to falling shots. Communication between the FO and gunners generally used radio.

The FO Simulator was created to save on military operation costs [2]. It increases the ability of the FO to direct the shot, make corrections to the shot's fall and determine the formation of the shot against the target based on the coordinates that have been obtained.

The topic of discussion in this study is how to model artillery fire formations based on the target coordinates sent by the FO.

2. Design of FO Simulator

2.1. Forward Observer Position

The artillery fire formation was designed to meet the needs of the FO Simulator. It was built using the unity game engine [3]. Here is the design of the FO Simulator.

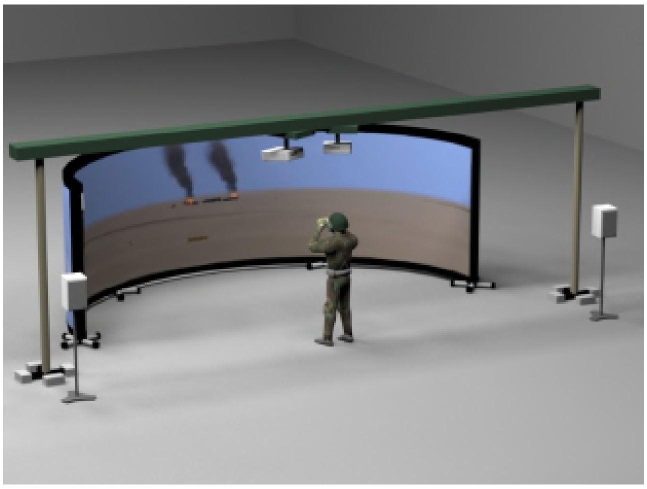


Figure 1 Forward Observer Simulator Design

Figure 1 shows the design of the FO Simulator in which the FO observes the target using a binocular. The target of this simulator is using Non-Playable Character (NPC) [4]. After obtaining the target coordinates, the FO requests a shot to the gunner.

The position between the FO and artillery can be seen in the following figure[8].

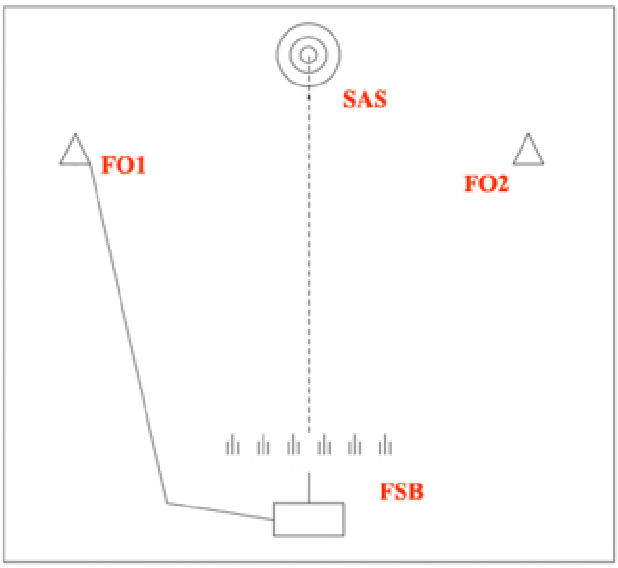


Figure 2 Forward Observer Position

Information:
FO1: Forward Observer 1
FO2: Forward Observer 2
FSB: Fire Support Base
SAS: Target

Figure 2 shows that the position of the FO is near the target. Meanwhile, the artillery was far away from the target. The number of FO can be more than one.

The FSB is a temporary firing base for artillery, generally having six 105 millimeter or 155 mm howitzers [5]. The positioning of the FSB varies depending on the terrain [6].

2.2. Shot Formation Modeling

The artillery fire formation consists of several types of fire. The types of shots were Tama, Tamu, Seka, Seki and Lingkar. Mathematical models were created to visualize these types of shot formations [7].

Here are the input parameters used to determine shot formation.
x = coordinates of the target LCO x
y = coordinates of the target LCO y
α = principal angle
ls = target width
r = radius

Here is the formula for each type of fire if there are six artillery pieces (a).

2.2.1. TAMA Shot

Xs[0,0]=x-(ls/a*0) * cos α	Ys[1,0]=y-(ls/a*0) * cos α
Xs[0,1]=x-(ls/a*1) * sin α	Ys[1,1]=y-(ls/a*1) * cos α
Xs[0,2]=x-(ls/a*2) * sin α	Ys[1,2]=y-(ls/a*2) * cos α
Xs[0,3]=x-(ls/a*3) * sin α	Ys[1,3]=y-(ls/a*3) * cos α
Xs[0,4]=x-(ls/a*4) * sin α	Ys[1,4]=y-(ls/a*4) * cos α
Xs[0,5]=x-(ls/a*5) * sin α	Ys[1,5]=y-(ls/a*5) * cos α

2.2.2. TAMU Shot

Xs[0,0]=x+(ls/a*0) * cos α   Ys[1,0]=y+(ls/a*0) * cos α
Xs[0,1]=x+(ls/a*1) * sin α   Ys[1,1]=y+(ls/a*1) * cos α
Xs[0,2]=x+(ls/a*2) * sin α   Ys[1,2]=y+(ls/a*2) * cos α
Xs[0,3]=x+(ls/a*3) * sin α   Ys[1,3]=y+(ls/a*3) * cos α
Xs[0,4]=x+(ls/a*4) * sin α   Ys[1,4]=y+(ls/a*4) * cos α
Xs[0,5]=x+(ls/a*5) * sin α   Ys[1,5]=y+(ls/a*5) * cos α

2.2.3. SEKA Shot

Xs[0,0]=x+(ls/a*0) * sin α   Ys[1,0]=y+(ls/a*0) * cos α
Xs[0,1]=x+(ls/a*1) * sin α   Ys[1,1]=y+(ls/a*1) * cos α
Xs[0,2]=x+(ls/a*2) * sin α   Ys[1,2]=y+(ls/a*2) * cos α
Xs[0,3]=x+(ls/a*3) * sin α   Ys[1,3]=y+(ls/a*3) * cos α
Xs[0,4]=x+(ls/a*4) * sin α   Ys[1,4]=y+(ls/a*4) * cos α
Xs[0,5]=x+(ls/a*5) * sin α   Ys[1,5]=y+(ls/a*5) * cos α

2.2.4. SEKI Shot

Xs[0,0]=x+(ls/a*0) * sin α   Ys[1,0]=y+(ls/a*0) * sin α
Xs[0,1]=x+(ls/a*1) * sin α   Ys[1,1]=y+(ls/a*1) * cos α
Xs[0,2]=x+(ls/a*2) * sin α   Ys[1,2]=y+(ls/a*2) * cos α
Xs[0,3]=x+(ls/a*3) * sin α   Ys[1,3]=y+(ls/a*3) * cos α
Xs[0,4]=x+(ls/a*4) * sin α   Ys[1,4]=y+(ls/a*4) * cos α
Xs[0,5]=x+(ls/a*5) * sin α   Ys[1,5]=y+(ls/a*5) * cos α

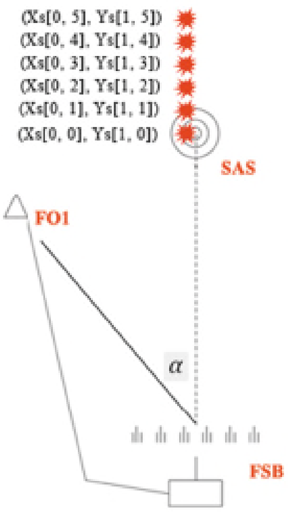
2.2.5. Lingkar Shot

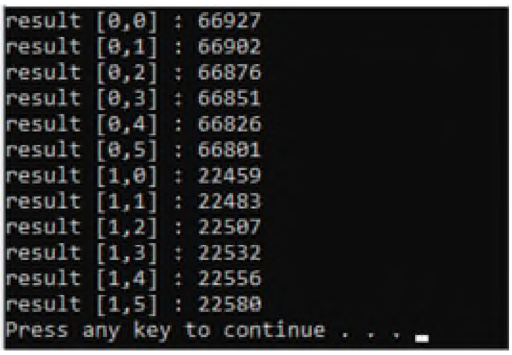
Xs[0,0]=x+r*sin α*sin(0*π/180)   Ys[1,0]=y+r*cos α*cos(0*π/180)
Xs[0,1]=x+r*sin α*sin(-60*π/180)   Ys[1,1]=y+r*cos α*cos(-60*π/180)
Xs[0,2]=x+r*sin α*sin(60*π/180)   Ys[1,2]=y+r*cos α*cos(60*π/180)
Xs[0,3]=x+r*sin α*sin(-120*π/180)   Ys[1,3]=y+r*cos α*cos(-120*π/180)
Xs[0,4]=x+r*sin α*sin(120*π/180)   Ys[1,4]=y+r*cos α*cos(120*π/180)
Xs[0,5]=x+r*sin α*sin(180*π/180)   Ys[1,5]=y+r*cos α*cos(180*π/180)

3. Result and Implementation

Tests were carried out to ensure that the visualization of the shot formation was as expected. The coordinate value is obtained from a binocular tool that can detect the target coordinates. The angle value was obtained from the FSB, FO, and SAS positions. Then the values are sent to the shooter.

The TAMA shot was tested by entering the coordinates LCO x = 66927, LCO y = 22459, α = 2377 and target width = 210. The results can be seen in Figure 3.

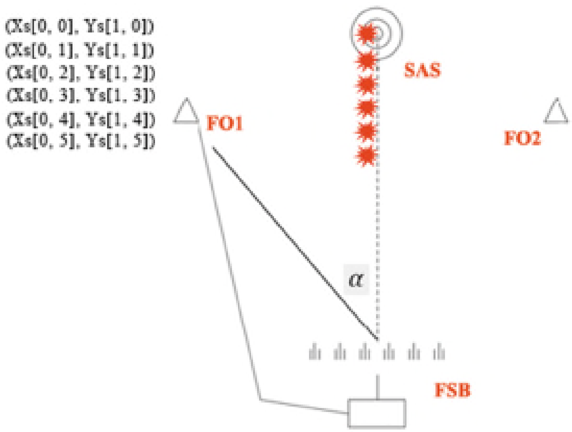


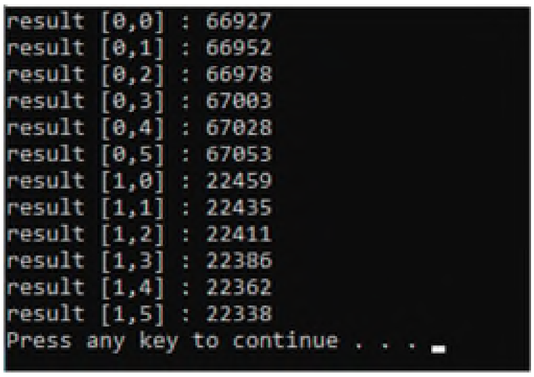


(a) (b)

Figure 3 (a) TAMA Shot, (b) Output Coordinates

Figure 4 shows the visualization and calculation results of the TAMU shot. The TAMU shot was tested by entering the coordinates LCO x = 66927, LCO y = 22459, α = 2377 and target width = 210.

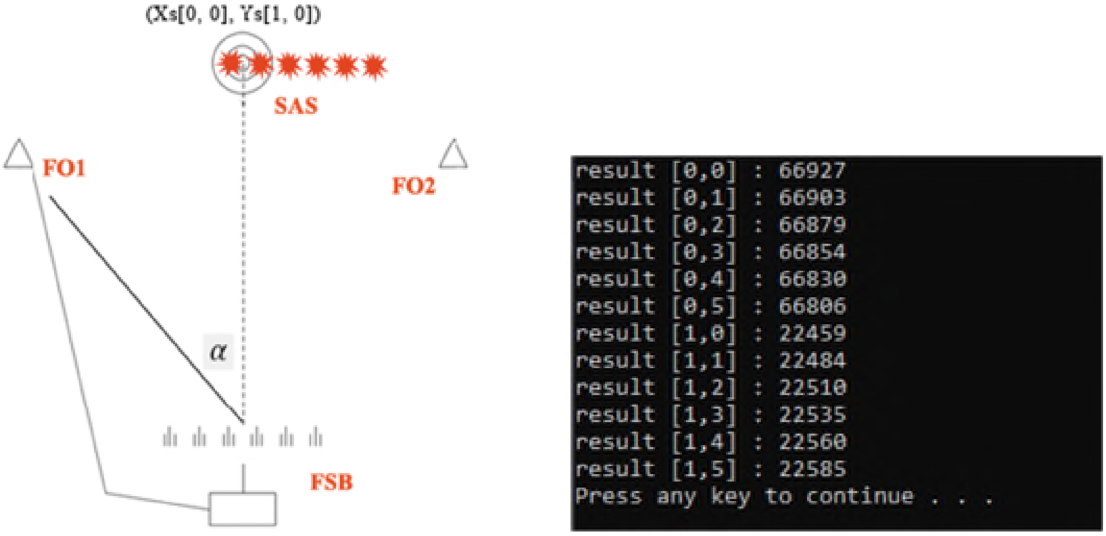




(a) (b)

Figure 4 (a) TAMU Shot, (b) output Coordinates

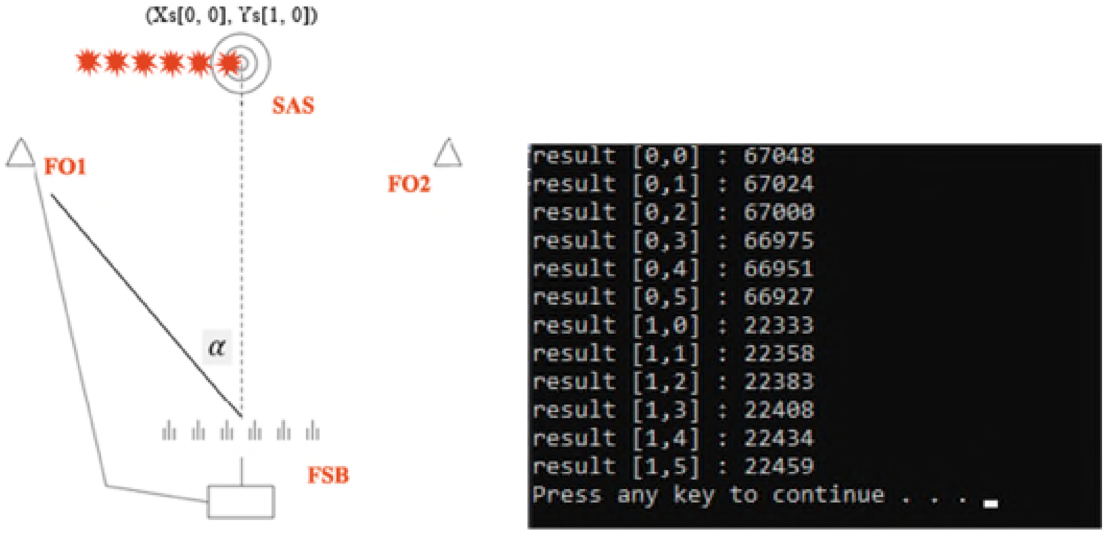
Figure 5 shows the visualization and calculation results of the SEKA shot. The SEKA shot was tested by entering the coordinates LCO x = 66927, LCO y = 22459, α = 2377 and target width = 210.



(a) (b)

Figure 5 (a) SEKA Shot, (b) Output Coordinates

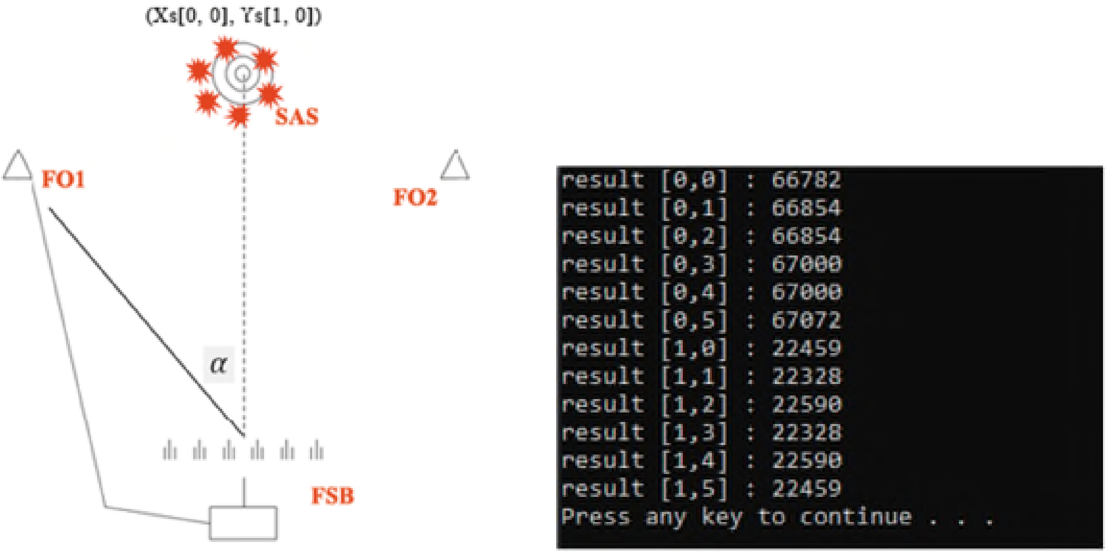
Figure 6 shows the visualization and calculation results of the SEKI shot. The SEKI shot was tested by entering the coordinates LCO x = 66927, LCO y = 22459, α = 2377 and target width = 210.



(a) (b)

Figure 6 (a) SEKI Shot, (b) Output Coordinates

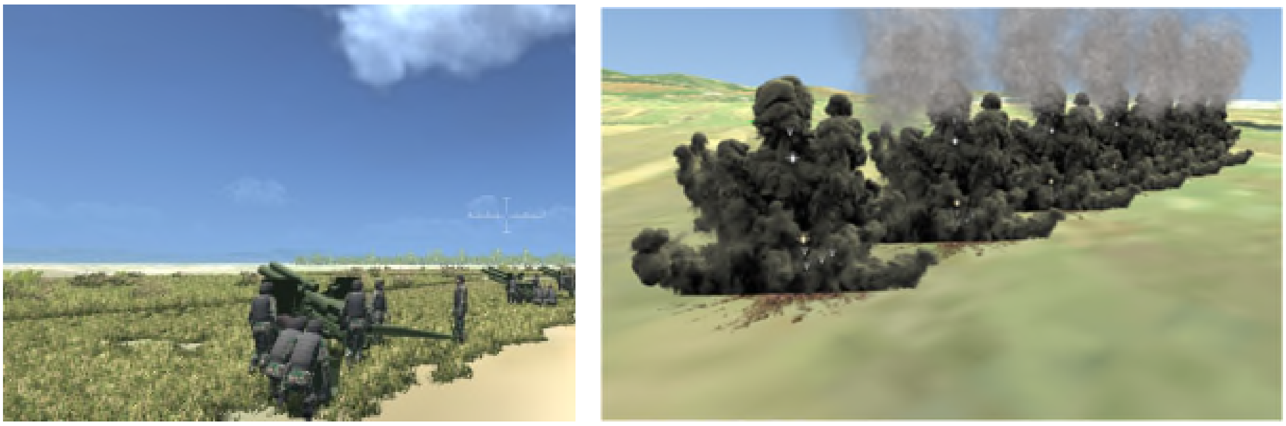
The visualization and calculation results of the LINGKAR shot can be seen in Figure 7. The LINGKAR shot was tested by entering the coordinates LCO x = 66927, LCO y = 22459, α = 2377 and radius = 210.



(a) (b)

Figure 7 (a) LINGKAR Shot, (b) Output Coordinates

After testing is complete, the next step is to visualize it in 3D and implement it in the FO Simulator. Visualization of the FSB position, FO position and examples of explosion results can be seen in Figure 8.



(a) (b)

Figure 8 FSB Position and SEKA Explosion Results: (a) FSB, (b) Explosion

Figure 9 is an example of target positioning and visualization of a LINGKAR shot hitting the target.

(a) (b)

Figure 9 SAS Position and LINGKAR Explosion Results: (a) SAS, (b) Explosion

4. Conclusions

Artillery fire modeling and visualization are useful to support the FO Simulator and save on shooting practice costs. The results of the tests that have been carried out conclude that the formula created can be implemented. With this simulation, FO and firefighters can practice calculating target coordinates and see the results of shots visualized in 3D.

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