STUDY ON UNIVERSAL VULNERABILITY/LETHALITY ASSESSMENT SOFTWARE

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In this paper, we describe the design and the implementation of VM-SLAS(Survivability and Lethality Assessment Software based on Virtual Mode technology); VM-SLAS is a new set of tools to study warhead Lethality and TBM vulnerability. The many models are presented, such as geometical, physical and functional description of TBM. The framework of assessment system is established. Based on investigating the development of UVLAS(Universal Vulnerability/Lethality Assessment Software) and the experience we developed VM-SLAS, we analyze the basal principle(universality, consistency, modularization, veracity, etc), and establish system framework of UVLAS, finally function modules of every subsystem(target vulnerability subsystem, warhead lethality subsystem, intersection subsystem, damage assessment subsystem, etc) are illuminated. The proposition of developing UVLAS is provided.

1 INTRODUCTION

VLAS is widely used to assess warhead lethality, target vulnerability, warhead design and damage assessment. Today many analysis method have been established, such as hit to kill model, damage tree model, DSVM(Degraded States ulnerability Methodology), etc, and the corresponding vulnerability/lethality assessment softwares have been developed which have the different application range. BRL-CAD is a representative target description software in CSG(Constructive Solid Geometry) solid modeling system, which includes an interactive geometry editor, parallel ray-tracing support for rendering and geometric analysis and path-tracing for realistic image synthesis tools. The other softwares such as MEGA-GF, TARVAC, LIBRA, etc are integrated vulnerability/lethality assessment. For example, TARVAC can deal with stationary and (fast) moving targets (such as air fighters and missiles) while the terminal

ballistic threat-target configuration has to be determined by other models. Based on the available threat mechanisms, it can handle new ammunition configurations without modification. The traditional "compartment method" is also included in the method [1].

We have developed the warhead lethality description software and vulnerability/lethality assessment software. Lethality simulation software for fragmentation warhead is developed based on numerical simulation and theoretical analysis. The software is fit not only for axismmetric but also for unsymmetrical warhead. The whole process description of fragment field is introduced, fragment movement and fragment impacting on target can also be obtained.[2]. Warhead lethality description is the strong emphasis of investigation. LATFW (Lethality Assessment of Typical Fragmentation Warhead) is establishen based on fragment shot-line model. The software can realize the simulation for static, dynamic and actual combat, i.e., it can assess lethality of typical warhead [3].

In this paper, by investigating and analyzing development situation, existent problem and development trend of vulnerability/lethality assessment software, we developed VM-SLAS, which is an example to discuss UVLAS. The characteristics of UVLAS are analyzed, including consistency, universality, modularization, expansibility and veracity, etc. Based on the experience of VM-SLAS, system framework of UVLAS is established, which consists of four necessary subsystems, i.e., target vulnerability subsystem, warhead lethality subsystem, intersection subsystem of warhead/target and damage assessment subsystem. In addition, two added subsystems, i.e., data management and pre/post processing are introduced in UVLAS. The necessary function analysis of each subsystem is discussed.

2 VM-SLAS

VM-SLAS is a new software package to study warhead lethality and TBM vulnerability [4]. it aims at fragmentation warhead and KE-rod warhead. Computer simulation, database and VRML are adopted in the software, which can get more precision of TBM vulnerability. Based on face-check algorithm, the model of warhead/target and damage assessment is obtained.

2.1 Simulation Model

VM-SLAS is a triplex system involved TBM, Warhead and intersection relation of warhead/target, which includes target vulnerability model, warhead lethality model, intersection model and damage assessment model.

2.1.1 Target vulnerability model

Target description is an important component of vulnerability analysis. The accuracy of simulation results is directly decided by the accuracy and particular of

target description. Two methods, discrete cell algorithm and VRML technique, are introduced to describe TBM geometric model. The model of TBM is built with discrete cell algorithm and the geometry data are saved in the database. But the geometry data of TBM, which is established by CAD software, is saved by VRML technique, i.e., by unscrambling VRML files. According to TBM functional vulnerability description, TBM structure is divided into three level based on structure and function of TBM, which are system level, groupware level and part level. TBM damage model is established by DSVM(Degraded states vulnerability methodology).

2.1.2 Warhead lethality model

Fragmentation warhead and KE-rod warhead are mainly investigated in VM-SLAS. Two damages to target are blast and fragment/KE-rod, while the latter is more dominant. So only the damage by fragment/KE-rod is considered in VM-SLAS. On the basis of shot line model [3], the model is simplified which includes velocity distribution model, density distribution model and air drag model.

2.1.3 Intersection model of warhead and TBM

Intersection model of warhead and target, which mainly includes coordinate system and intersection parameter, is a key component of vulnerability/lethality assessment. The correct coordinate system would reduce the complexity of mathematic derivation and calculation velocity. Intersection parameters include missile velocity, projection angle, target velocity and pitching angle, etc. Specially, stochastic factor must be considered during in intersection model, so Monte Carlo method is employed for describing stochastic problem.

2.1.4 Damage assessment model

Damage assessment model is used to assess the damage result of warhead under the specific condition of Warhead-TBM intersection. The general methods include the statistical method of test data, the integral method of probability density, and the simulation method based on Monte Carlo. With damage assessment technique and computer simulation, damage assessment model based on face-check algorithm is built in the paper, which can offer the quantification results of warhead-TBM intersection. Fig.1 shows face-check algorithm, which is based on shot-line model. Because fragmentation warhead consists of thousands of shot-line, time effect of the algorithm must be taken into account.

Function damage of groupware is calculated by structure damage based on face-check algorithm, then function damage of TBM is gained. Based on function damage model, TBM damage probability is calculated by $\lim_{N\to\infty}\frac{M}{N}$, in which N is the simulation times and M is the destroy times of TBM.

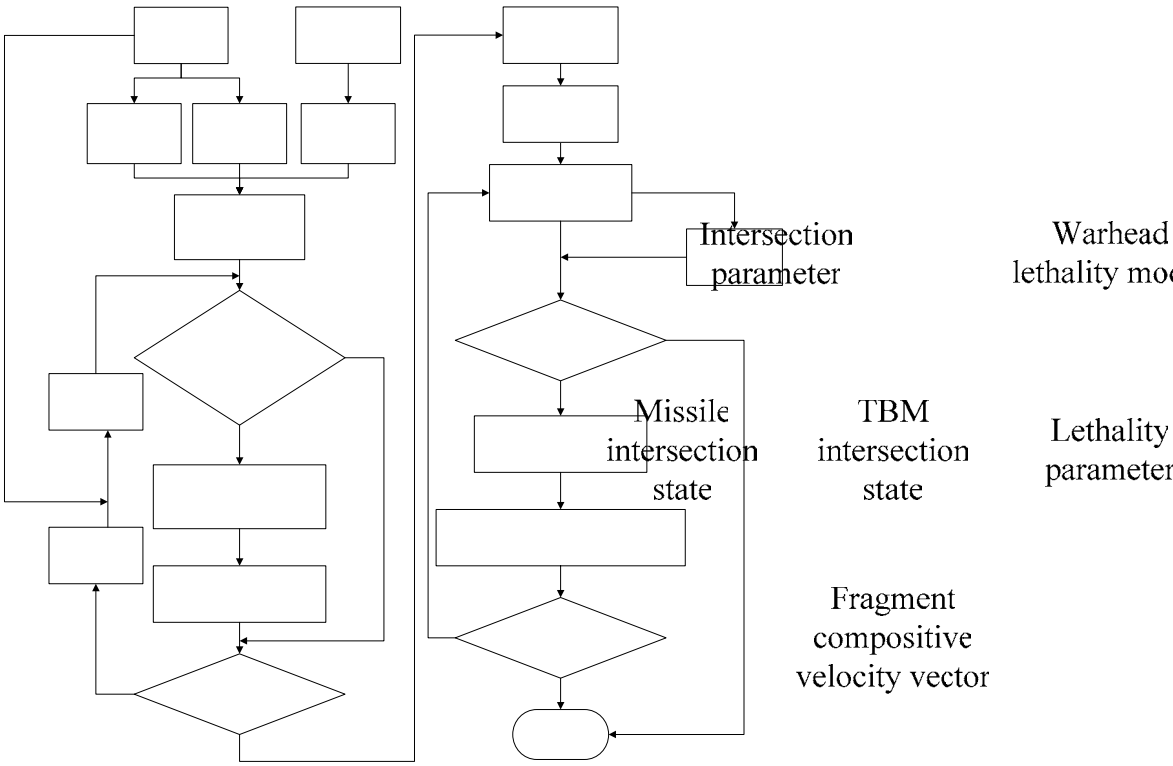


Figure 1. Face-check algorithm

2.2 Database design

Each function module would switch data with database frequently, so dynamic datase technique is introduced to manage all data(character parameter, temporary data, visulization data). Database design flow chart is shown in fig. 2.

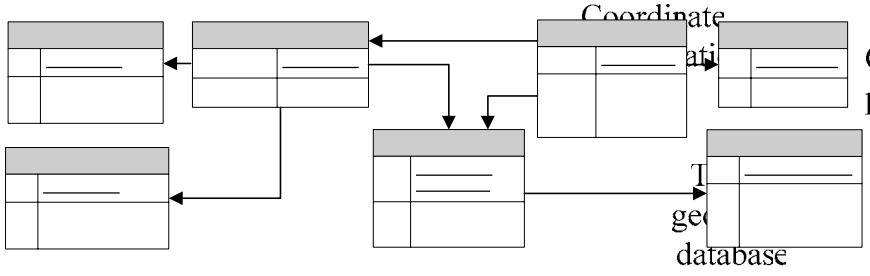


Figure 2. Database structure of VM-SLAS

Database includes

(1) Structure data: target geometry information is saved in it. “TabPart” includes character information of groupware, such as material color, cell number and etc. “TabFace” includes cell number and point number. “TabPoint” includes point coordinate.

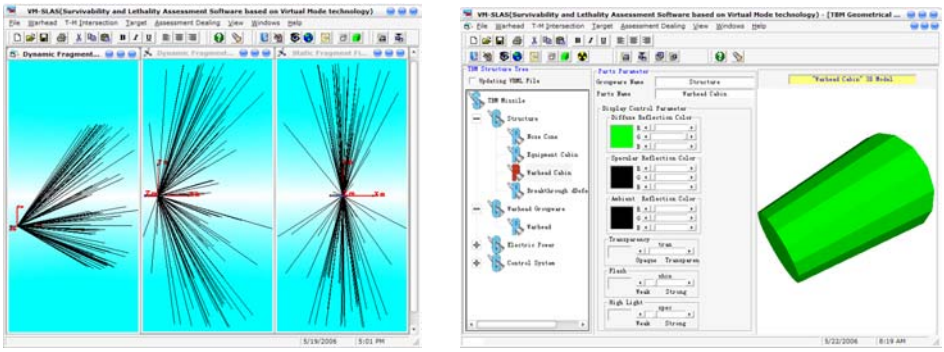
(2) Intersection data: it represents the location relation of warhead and TBM, “TabRelation” inclueds pitching angle, yawing angle, velocity and etc.

(3) Warhead lethality data: “TabFragment” includes warhead characteristic parameter and power parameter, such as fragment initial velocity, fragment mass and dispersal angle.

(4) Target vulnerability data: it consists of target structure table(tabPart, tabFace, tabPoint), target function table(tabTarTree) and target characteristic table(tabTarMat).

2.3 EXAMPLE ANALYSIS

TBM vulnerability analysis is investigated with VM-SLAS for an fragmentation warhead [4]. The static and dynamic distribution of fragment shot-line fields and target vulnerability description are shown in fig. 3(a) and (b), respectivily.



(a) Warhead lethality description (b) target vulnerability description

Figure 3. Interfaces of VM-SALS

3 UVLAS

3.1 Basic Principle

The design and developpment of vulnerability/lethality assessment software must follow the principle of software engineer. Furthermore, the development has unique and professional characteristic.

3.1.1 Universality

Universality is an important characteristic during the development of vulnerability/lethality assessment software. In the past, many softwares were developed only for specific purpose, which were difficult to be developed and generalized. For a general UVLAS, four aspects must be consided, i.e. target vulnerability description, warhead lethlaity description, intersection between warhead/target and damage assessment.

3.1.2 Consistency

Vulnerability/lethality assessment software is established based on vulnerability/lethality assessment method, so the adopted method must be consistent with exist vulnerability/lethality assessment method, which includes lethality description method(experiential formula, theory analysis, numerical simulation), target vulnerability analysis method(point model, damageable area model, high precision model), intersection analysis method(graph analysis model, Monte Carlo model) and damage assessment method(hit to kill model, damage tree model, damage table model, DSVM model).

3.1.3 Modularization and expandability

Universality is the objective demand of assessment software development, and modularization is the basis of universality. Modularization guarantees the implementation of expandability. According to the demand of modularization, each function of system must be packaged in a module. The module should have input and output interfaces. Data flow of the module are independent among modules and data exchanging are completed with uniform fomat file.

3.1.4 Accuracy and efficiency

Accuracy of assessment software is determined by precision of assessment model and objectivity of corresponding data, so model checking and verification must be employed. At the same time, the principle of software engineer should be used in software development, i.e., eliminating program error and paying attention to software test. Furthermore, assessment process spends a long time, then, efficiency should be taken into account in simulation model, simulation algorithm and simulation hardware platform. Assessment software ought to provide different selection of simulation accuracy and simulation algorithm so that user can choose the proper model and algorithm for different simulation objective, while the relationship of accuracy and efficiency is intercoordinated.

3.2 System framework

By investigating and analyzing existent problems and development trend of

vulnerability/lethality assessment software, We find that UVLAS should consist of four necessary subsystems, i.e., target vulnerability subsystem, warhead lethality subsystem, intersection subsystem of warhead/target and damage assessment subsystem. Fig. 4 shows system framework. In addition, UVLAS should also include two additional subsystems, i.e., data manage subsystem and pre/post processing subsystem.

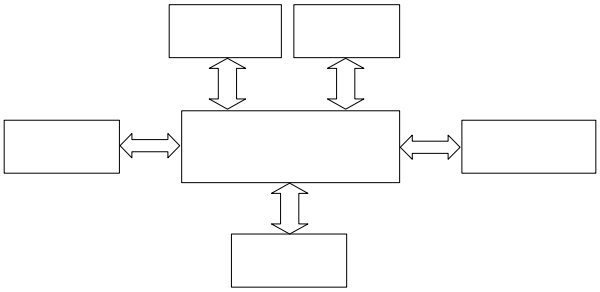


Figure 4. System framework of UVLAS

3.3 Function module

3.3.1 Target vulnerability subsystem

This subsystem describing target vulnerablity include target geometry model, structure damage model and function damage model, in which target geometry, structure damage and function damage are given and provided for damage assessment subsystem.

3.3.2 Warhead lethality subsystem

Warhead lethality is consist of static lethality and lethality of actual combat. Static lethality illuminates warhead target data, and includes blast pressure, fragment mass, fragment density and dispersal angle. Lethality of actual combat is relative because of correlating with target vulnerability and intersection relationship. For example, damage radius for personnel target is bigger than that for armor target.

3.3.3 Intersection subsystem of warhead and target

This subsystem manages the intersection parameter describing intersection relationship, such as missile velocity, target velocity, pitching angle, yawing angle, and etc. For air-defense warhead, warhead fuze coordination must be considered in intersection model, so the corresponding parameters ought to be introduced, which are the efficiency of warhead fuze coordination, the optimal detonation location.

3.3.4 Damage assessment subsystem

Damage assessment subsystem is the most important but the most difficult subsystem. It is used to assess the interaction result of warhead/target which is affected

by target vulnerablity model, warhead lethality model and intersection subsystem model. The subsystem includes structure damage module and function assessment module. Fig. 5 is the flow chart of damage assessment subsystem.

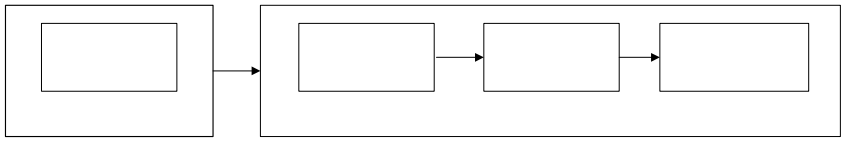


Figure 5. Flow chart of damage assessment subsystem

As shown in fig. 5, target functional state can be caculated and assessment of target systme state is gained on the basis of the result of structure damage. Then we can calculate target operational state and complete function assessment.

The visualization of UVLAS could be achieved by pre/post processing subsystem, which can provide the interface of CAD and CAE. All function of dealing with data may be found in Data manage subsystem, while dynamic database technique is integrated in the same subsystem.

Calculating physical state

Calculating functional stat

structure damage module

4 Conclusion

Based on investigating and analyzing the development of UVLAS, analyzing the design and implementation of VM-SLAS, we analyze the basic principle, system framework and function module of UVLAS. The professional characteristic is also discussed in the paper. The principle of software engineer should be follow in designing and developing UVLAS. This work will be help for the design and implementation of UVLAS.

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