Application of Hopfield neural network on the energy-saving robot path finding and robot arm control.

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Contents

Abstract

In this two-month stage, the effect of the depletion of control rods is studied. The origin, consequences of this effect are researched and a model of prediction using deep learning is set up.

For nuclear reactors where control rods are inserted in long periods of time, the radiation will cause the atom densities to change significantly. This will introduce a new phenomenon called the *burnup* of control rods. The Monte Carlo simulation software, Serpent, developed by VTT Team is used to study the origin and consequences of this effect. A method of quantification of the burnup of control rods is proposed and verified. Furthermore, due to the existence of multiple factors that could effect this phenomenon and its consequences, a deep neural network is set up to predict the change in macroscopic cross section of control rods introduced by its burnup. The error in the results is fairly good.

摘要

这两个月的实习中, 我学习了反应堆中的控制棒的燃耗效应，研究了这个效应的源头和影响并设计了一个深度学习的预测模型。

对于控制棒长期插入反应堆的情况，长期的辐射会导致控制棒内部核素发生变化从而产生” 控制棒燃耗”。VTT 团队开发的蒙特卡洛模拟软件 Serpent 被应用在了这个效应的源头和影响的模拟上。同时我提出了一个量化控制棒燃耗效应的方法并对其进行了验证。在此基础上，由于存在多个因子都对这个效应有各种程度的影响，我搭建了一个深度神经网络来预测由于控制棒燃耗所引起的控制棒宏观截面变化。得到了还不错的结果。

Presentation of the environment of work

1.1 Presentation of company

China General Nuclear Power Research Institute Co., Ltd. (formerly "Zhong Kehua Nuclear Power Technology Research Institute Co., Ltd.", officially changed its name on October 28, 2015, hereinafter referred to as the research institute) is a national energy nuclear power plant nuclear-level equipment research and development (experimental) center and a construction support unit of the nuclear fuel element research and development (experiment) center. The research institute has a registered capital of 1.225 billion. The company has 10 professional business centers (project departments), 1 branch and 1 holding subsidiary. The office area covers Beijing, Shenzhen, Shanghai, Chengdu, Yangjiang and other places. There are more than 1,400 professional scientific and technical personnel.

The Research Institute was registered and established on November 8, 2006, and was formed by China General Nuclear Power Group Co., Ltd. (formerly China Guangdong Nuclear Power Group), Chinese Academy of Sciences and Huaneng Group in accordance with a 7:2:1 share ratio.

In November 2009, China General Nuclear Power Group achieved 100% holding of the research institute through share repurchase. In May 2014, China General Nuclear Power Co., Ltd. was established, and China General Nuclear Power Group transferred all the shares of the research institute to China General Nuclear Power Co., Ltd.

As the most important nuclear power technology research and development platform of China General Nuclear Power Group, the research institute is strategically positioned to lead the group’s technological innovation and development, and provide technical support for the group’s core business of nuclear power and new energy business sectors. It will give full play to the driving force following operations and engineering. The "third pole" role of the group’s strategic development focuses on the research and development breakthroughs of high-end nuclear energy and new energy technologies, leading the group’s technological progress, and providing technical support and reserves for the group’s future strategic development.

The headquarter of the institute is located in Shenzhen, with 10 business centers (project departments), namely, nuclear fuel R&D and design center, reactor engineering design and safety research center, system engineering and transformation center, equipment R&D center, reactor engineering experimental research center, and environmental engineering Center, small reactor R&D and design center, small reactor market development department, experimental reactor engineering project department, accident fault-tolerant fuel research and development project department; Beijing branch office in Beijing; 1 holding subsidiary China General Nuclear Power (Beijing) Simulation Technology Co., Ltd.

The research institute is a specialized platform for scientific research and development, professional technical services, and high-end equipment manufacturing of the group. The main research directions include the research and development of new nuclear power reactors, fuels and related key technologies and equipment, the research and development of new energy and environmental protection technologies, and the main business The fields are scientific research and development, professional technical services, high-end equipment manufacturing and comprehensive utilization of nuclear energy.

The main business areas of the Institute are currently divided into 10 major sections: the reactor engineering business section, which mainly focuses on core design and fuel management, thermal hydraulics and transient analysis, safety analysis and fluid system research, and severe accident analysis as the core tasks; fuel; The business segment mainly focuses on fuel research and development, fuel cycle technology research, etc.; the engineering transformation business segment, with nuclear power plant mid- and long-term engineering transformation, common and major technical issues research as its core tasks; nuclear power plant equipment and special tools research and development and industrialization segment, Take nuclear power plant nuclear-level equipment and special tools key technology research and development and industrial chemical industry as core tasks; simulation technology business segment, to build a simulation technology platform, provide a full range of nuclear power plant simulator products, and develop power plant functional simulation, performance testing, analysis technology and other simulations Technology and the provision of simulator operation and maintenance services are the core tasks; the advanced nuclear energy technology section focuses on the development, design and demonstration of advanced reactors such as small reactors and lead-based fast reactors as the core tasks, while closely tracking the next generation of nuclear power technologies; reactors The engineering experiment section focuses on the construction of reactor engineering experimental equipment, experimental technology research and experimental organization and implementation; the new energy business section focuses on the research of new energy technologies such as wind power, solar energy, and hydrogen energy as the core tasks; the environmental business section focuses on nuclear power plants The core tasks are the treatment of three wastes and the development of civil environmental protection technologies and equipment; in the software sector, the core tasks are the development of special design and analysis software for nuclear power.

1.2 Presentation of the reception service

The hosting service of this stage is the Software Institute of the reactor engineering design and safety research center, whose role is to develop simulation softwares that could be used in the design and construction of nuclear power plants. As described in the previous section, the reactor R&D and design center is one of the 10 business centers of the research institute and the software institute is one of the many institutes in the reactor R&D and design center.

This institute provides software for other institutes and centers to use in various concepts like the evaluation of designs. Other institutes provides demands and play the role of customers for software institute.

Recently, the institute tends to integrate the effect of the *burnup* (will be introduced later) of control rods to one of its nuclear simulation software in order to make the software capable of simulating more types of reactors in more generous conditions. This software uses deterministic approaches to simulate the physical parameters in the reactor in macroscopic scale. The principle work of this stage is to research this effect, including its origin, its consequences, methods of quantification and prediction using Monte Carlo simulation softwares. It is then possible to provide formula that could be used in deterministic softwares.

The intern works under the instructions of a Core Software Lead Engineer who is also the corporate mentor of the intern. This engineer is also one of the principles and developers of the software and could provide details of the simulations that should be carried out. In addition, the intern could seek helps from an assistant engineer in the same office who is also responsible for this software. For the usage Monte Carlo simulation softwares, instructions are given by a colleague in a nearby office who is expert in using Monte Carlo simulation softwares. Middle-term reports are presented to the corporate mentor along with other colleagues in the same office.

Presentation of the activities carried out during the internship

2.1 Presentation of objectives

The burnup of the fuel is one of the most important part in reactor simulation softwares, while the depletion of the control rods (which will also be called the *burnup* of control rods in following sections, noted as B_{cr}) is rarely considered. In most cases, this will introduce no great error thanks to the short period of time in which the control rods are inserted. However, in rod-controlled small reactors, where the period of insertion matches the life of the reactor, such effect could no longer be neglected.

Recently, the development of a deterministic software in CGN requires such consideration. The software requires calculating **the change in the fuel assembly's macroscopic cross section introduced by the insertion of control rods.** This change is previously found to be mainly related to three factors: concentration of boron (C_B), temperature of control rod (T) and density of moderator (ρ) (Enrichment of *U235* and the geometry are considered as fixed so are not included as variables.).

$$(\Delta\Sigma)^{cr} = f_0(C_B, T, \rho) \tag{2.1}$$

The correlation f_0 was calculated by interpolation of a table of values.

It is found in a preliminary research that the influence of the burnup of control rods is also related to these parameters. So it is impossible to simply correct the correlation by simple manipulations like, for example, adding a burnup correction factor.

$$(\Delta\Sigma)^{cr} = f_0(C_B, T, \rho)F(B_{cr}) \tag{2.2}$$

The problem of this method is that this burnup correction factor is, in addition to the burnup of control rods, also related to the three parameters.

$$F = f_F(C_B, T, \rho, B_{cr}) \tag{2.3}$$

So instead of correcting existing correlations, we could build directly new correlations that include B_{cr}.

$$(\Delta\Sigma)^{cr} = f_1(C_B, T, \rho, B_{cr}) \tag{2.4}$$

This correlation could be calculated by building another table, or a new innovative method, by training a deep neural network. And it's the final objective to **obtain this correlation** in no matter which form.

2.2 Presentation of the methods and procedures used

2.2.1 Software

The software chosen for Monte Carlo transport simulations is SERPENT which is specially designed for nuclear reactors. It is developed by a Finnish research team in VTT technology research center based on continuous energy. The version is 2.1.21 which is announced in June 2014. It is very easy to perform burnup calculations in SERPENT without needs to couple extern solver. Users need only to set up the burnup intervals and some normalization parameters to perform the calculations. It is also very convenient to track the atom density change of nuclides since a mere configuration of the inventory is enough. The output of the software is MATLAB scripts that could be read directly and manipulated easily in MATLAB.

2.2.2 Model information

Model geometry

A typical fuel assembly consisting of 17×17 rods of a PWR is used. No Gd rods are included. The guide tube in the center is filled with water. Other guide tubes are filled with *Ag-In-Cd* control rods. Gaps in these rods are not considered except the water between control rod's outer diameter and guide tube's inner diameter. In order to take account of the self-shielding problem of control rods, it is divided into 3 circles in burnup calculations.

Final geometry is shown in Fig 2.1. The black triangle indicates the part that is defined explicitly in the model. The other parts are generated using symmetries.

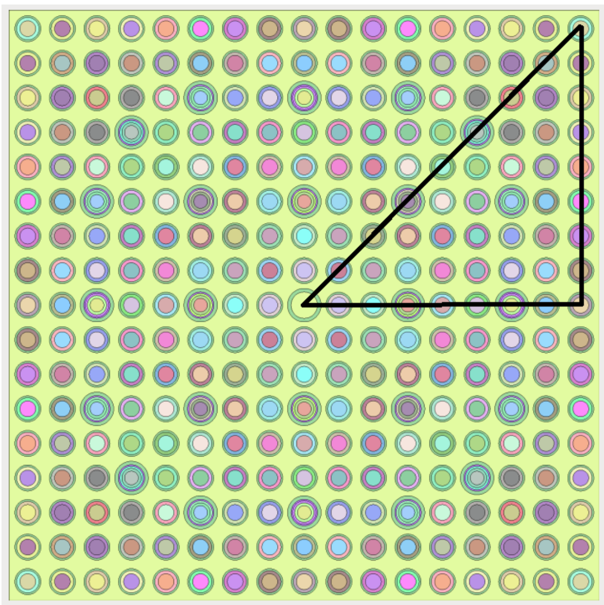


Figure 2.1: Geometry drawn with Monte Carlo simulation software

Material details

For the cladding of fuel rods and guide tubes, optimized ZIRLO is used.

For the cladding of control rods inside guide tubes, stainless steel type 304 is used.

Ag-In-Cd alloy is used as the neutron absorber material for control rods.

Unless otherwise specified, water density is set to *0.68 g/cc* with boron concentration 600 ppm. Fuel enrichment is set to *4.2%*. Fuel temperature is set to *900 K*. Moderator and other claddings' temperature is set to *600 K*. Power density is set to *38.6 W/gU* for burnup calculations.

2.2.3 Quantification of the burnup of control rods

In order to research the effect of the burnup of control rods and further include it in a Deep Neural Network. It is necessary to find a physical quantity that could quantify the burnup of control rods. This physical quantity will be noted as B_{cr} in the following sections.

The most direct one is the change in the sum of the product of the atom density and the hot neutron absorption cross section of all nuclides in the control rod. It represents the decrement of the control rods' ability to absorb hot neutrons.

$$B_{cr0} = \Delta\Sigma_i N_i \sigma_{h,i} \tag{2.5}$$

where N_i is the atom density of the nuclide and $\sigma_{h,i}$ is the hot neutron absorption cross section of the nuclide. However, this value cannot be directly read from many fuel assembly simulation softwares. Then it is needed to find a physical quantity that is proportional to this quantity and that one has easy access to in simulation softwares.

The fuel assembly's macro burnup is used as a mean to represent the control rods' burnup in preliminary researches. However, this method is not very reasonable since in different fuel assemblies, the burnup of control rods could be very different as shown in Figure 2.2.

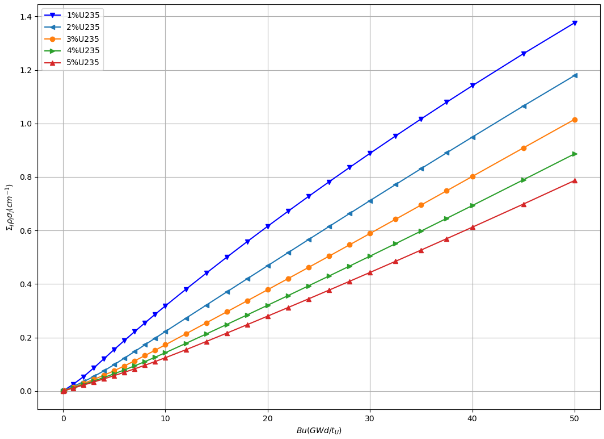


Figure 2.2: B_{cr0} as a function of fuel burnup for different enrichments

In most softwares, for simplicity the neutron energy is divided into two groups. One is the hot group (*0-0.625 eV*) and the other is the fast group (higher than *0.625 eV*). So we propose the following quantity

$$B_{cr} = \int_{\mathcal{T}} \phi_h dt + k \int_{\mathcal{T}} \phi_f dt \tag{2.6}$$

where $\mathcal{T}$ is the set of time in which the control rods are irradiated, ϕ_h, ϕ_f are the average neutron flux density in the control rods of hot group and fast group respectively. And k is called the *hot-fast group proportion factor*. By choosing the right k, one can prove that this B_{cr} in equation 2.6 is proportional to the B_{cr0} in equation 2.5.

By dividing the neutron energy group to hot and fast group. We'll have

$$\begin{aligned}
B_{cr0} &= \Delta\Sigma_i \sigma_{h,i} N_i \\
&= \Sigma_i \sigma_{h,i} \Delta N_i \\
&= \Sigma_i \sigma_{h,i} N_i (\sigma_{h,i} \int_{\mathcal{T}} \phi_h dt + \sigma_{f,i} \int_{\mathcal{T}} \phi_f dt) \\
&= \Sigma_i \sigma_{h,i}^2 N_i \int_{\mathcal{T}} \phi_h dt + \Sigma_i \sigma_{h,i} \sigma_{f,i} N_i \int_{\mathcal{T}} \phi_f dt
\end{aligned}$$

by noting $K = \Sigma_i \sigma_{h,i}^2 N_i$, $k = \frac{\Sigma_i \sigma_{h,i} \sigma_{f,i} N_i}{K}$, we have

$$\begin{aligned}
B_{cr0} &= K(\int_{\mathcal{T}} \phi_h dt + k \int_{\mathcal{T}} \phi_f dt) \\
&= K B_{cr} \qquad (2.7)
\end{aligned}$$

which proves the proportionality and the gives a method of calculating k. The results will be shown in the results chapter(3.2) where the goodness of this quantification is evaluated.

2.2.4 Neuron network setup

Prefix

In many circumstance, traditional methods use tables and interpolation to estimate multi-variable non-linear functions. Either because the correlation is too complicated to calculate or no explicit correlation could be obtained at all. In our case, the relation between the change in the macroscopic cross section of fuel assembly introduced by insertion of control rods and (C_B, T, ρ, B_{cr}) is later. No explicit correlations exist and regressions are difficult to carry out.

Machine learning is a very hot topic in recent years. It has changed the way people work in many fields, like picture recognizing or auto-mobile. Although this is not its main field of usage, it provides very good methods for regressions of multi-variable non-linear functions. The Universality Theorem proves that any continuous function with a finite number of inputs in a finite range can be approached as precisely as wanted by a single hidden layer neuron network with sufficient number of neurons with specific activation functions. This is the common case for functions in physics. This ensures that in our situation, it is possible to apply deep neuron network.

Data acquisition

At first, the material cards of control rods at different burnup(B_{cr}) are prepared by tracking atom density change and linking it to calculated B_{cr}. In this part, fuel burnup intervals are set to be very small to provide precise materials. There are 50 intervals between *0* and *50 GWd/tU* burnup. In fact, since the atom densities change nearly linearly as shown in section 3.1.2, interpolation will give very precise results in points other than these 50.

Table 2.1: Parameter range and normalization formula

variable	range	Unit	formula
C_B	[0, 3000]	*ppm*	$C_B = n \times 3$
T	[300, 900]	*K*	$T = 300 + n \times 0.6$
ρ	[0.6, 1.0]	*g/cc*	$\rho = 0.6 + n \times 0.0004$
B_{cr}	[0.0, 8.6]	10^{18} cm^{-1}	$B_{cr} = n \times 8.6.10^{18}$

Then a number N of random couples of $(C_B, T, \rho, B_{cr})_n$ are generated in range [0, 1000]. Real values (C_B, T, ρ, B_{cr}) can be calculated by the formula given in Table 2.1. Simulations show that Σ^{cr} changes very fast in range [0.0, 1.7] 10^{18} cm^{-1} (for normalized value [0, 200]) and much slower after. So in order to improve the efficiency of neuron network, values for B_{cr} are not chosen completely randomly but follows a Gaussian distribution whose mean value is *0* and standard deviation is *200*. We take the absolute values of this set of Gaussian distribution and values that exceeds *1000* are taken care of by a modulo operation.

Corresponding material cards are generated and put in the model described at 2.2.2. Then two calculations are performed. One with all control rods inserted and we could get a macroscopic hot neutron absorption cross section Σ^{cr}. The other one with no control rods inserted and we get Σ^{no_cr}. The change in macroscopic cross section is then calculated by

$$\Delta\Sigma^{cr} = \Sigma^{cr} - \Sigma^{no\_cr} \tag{2.8}$$

The $\Delta\Sigma^{cr}$ is also normalized to [0, 1000] by setting the minimal to *0* and maximal to *1000*. By this method, we'll get N sets of $(\Delta\Sigma^{cr}, C_B, T, \rho, B_{cr})_n$ which could be used for training a neuron network.

Neuron network details

We use TensorFlow.Keras to construct our neuron network for simplicity. TensorFlow is a mathematical Python library designed for building machine learning models. The version we used is *2.0.0*. Keras is now a submodule of TensorFlow that is very convenient for building simple neuron networks for general purposes. Setup of a model requires only several configurations of parameters, with no explicit design of the model required. In our model, only the most basic parameters need to be configured.

At the beginning, all the data are divided to two sets. One for training the model which takes *80%* data and the other for testing which takes the remaining *20%* data. Then all input will be divided by *1000* (range shrunk to [0, 1]) which is a standard normalized data range for neuron networks. Output values are between [0, 1000] which remain unchanged.

Keras Sequential is a good model for regressions, we add two dense layers with 2048 neurons each. In order to avoid overfitting problem, an early-stop function is defined. The function will monitor *var_loss* variable (the loss of network on the test data set) to detect if overfitting exists and stop the training as soon as the early-stop criteria is satisfied.

After the training is finished, *mean absolute error* is calculated on test data set to evaluate the goodness of the model.

Presentation of results

3.1 Influence of B_{cr} and its origin

3.1.1 Impact on the effective multiplication factor

In order to have a basic idea of how much the burnup of control rods could effect the fuel assembly, we compare the effective multiplication factor.

Using the model described in section 2.2.2, we calculate two sets of fuel assemblies. One has their control rods set as a burnable material, the other set as a non-burnable material. The effective multiplication factor in these two conditions is shown in Fig 3.1.

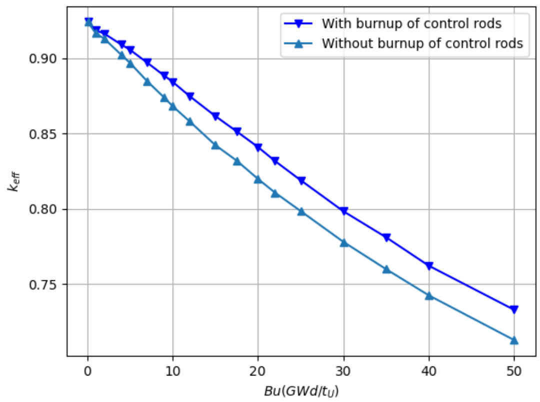


Figure 3.1: Effective multiplication factor as a function of fuel assembly burnup

The results show that, after a burnup of *20 GWd/tU*, the difference in k_{eff} could reach *2000 ppm*. It is a gap that could not be neglected. This confirms that in these kinds of nuclear reactors, where control rods are inserted in long periods of time, the burnup of control rods is a factor that mush be considered.

3.1.2 Origin of B_{cr}

In order to track the origin of this phenomena, the atom density of different nuclides in control rods is recorded. Fig 3.2 shows the change of atom density of different nuclides as a function of the burnup of fuel.

Ag107(σ_h = *45.2 barn*), *Ag109*(σ_h = *92.8 barn*) and *In115*(σ_h = *203.7 barn*) are the three main hot neutron absorber nuclides in control rods. Their atom density decreases very fast com-

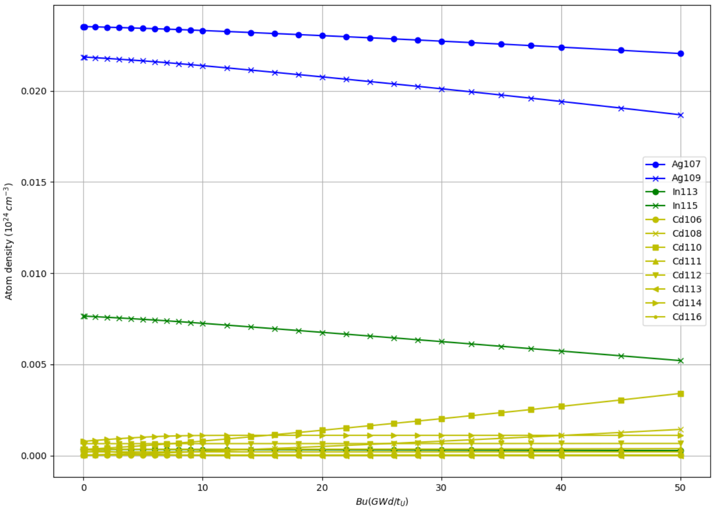


Figure 3.2: Nuclide atom density change as a function of fuel burnup

pared to other nuclides. After absorbing a neutron, they transfer to nuclides of other elements (mainly *Cd* and *Sn*) whose hot neutron absorption cross section is much smaller. This reduces the macroscopic hot neutron absorption cross section of control rods and causes the burnup of control rods.

3.2 Quantification of the burnup of control rods

Introducing the quantification method described in section 2.2.3 as the new representation of the burnup of control rods, we could get figure 3.3. k is calculated to be *0.03* using only the three main neutron absorbing nuclide *Ag107*, *Ag109* and *In115*.

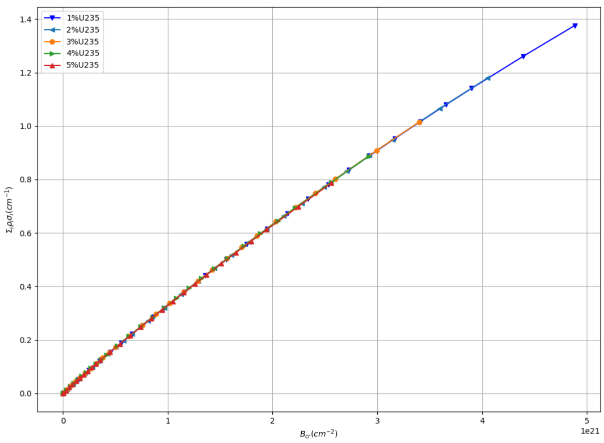
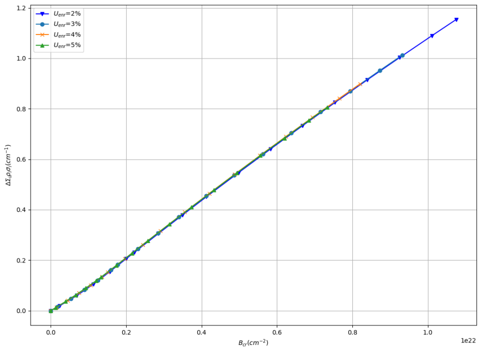
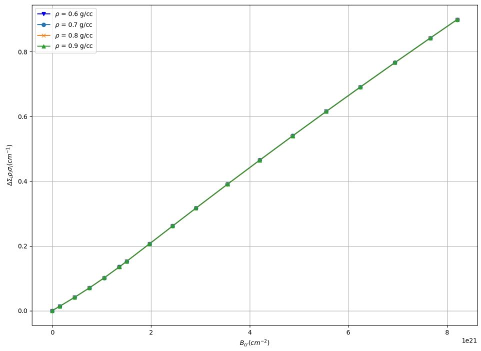


Figure 3.3: B_{cr0} as a function of B_{cr} using control rod's neutron fluxes for different enrichments

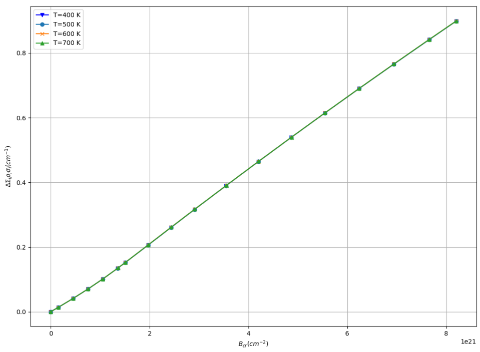
However, in some simulation softwares, it is still quite difficult to access to the neutron flux density in control rods. Simulation results show that it can be replaced by the average neutron flux density in the fuel assembly with a different k (*0.1* in our case). For the model we built, differences in *U235* enrichment, moderator density, moderator temperature and boron concentration are tested to have no effect on k. As shown in Figure 3.4.



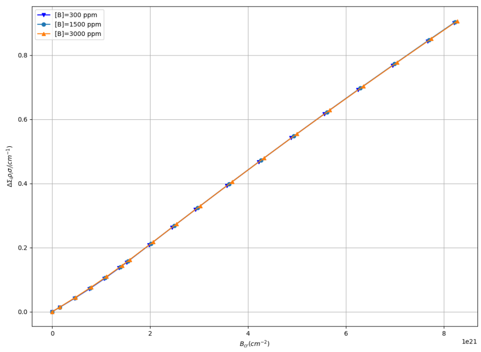
(a) Different enrichment



(b) Different moderator density



(c) Different temperature



(d) Different boron concentration

Figure 3.4: B_{cr0} as a function of B_{cr} using assembly's average neutron fluxes in different conditions

In the following sections, we'll use B_{cr} calculated with average neutron flux density in fuel assembly to quantify the burnup of control rods.

3.3 Results of the Deep Neuron Network

3.3.1 Regress results

N = *550* couples of $(\Delta\Sigma^{cr}, C_B, T, \rho, B_{cr})_n$ were calculated using the methods introduced in section 2.2.4. Several trainings are performed to avoid random effect. It takes averagely 1500 steps to train the model with *550* data points. The training process is fairly fast. The mean absolute error of the model on test data set is around *5* which means a mean relative error smaller than *1%*. The predictions of the test set comparing to the true values are shown in Fig 3.5.

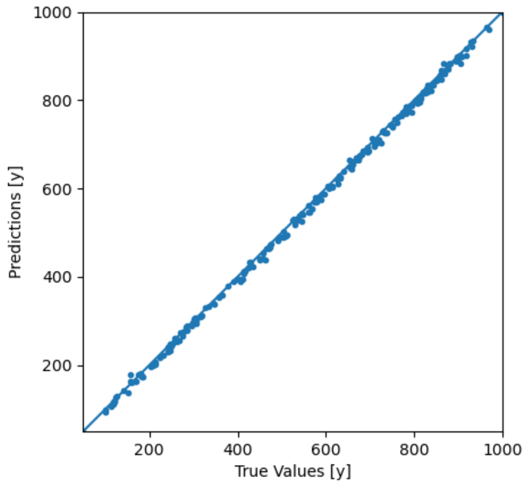


Figure 3.5: Deep neuron network predictions comparing to true values

Considering the errors introduced by the Monte Carlo simulation software itself, the result is very well fitted. The precision is also good enough for further usage in reactor core simulation softwares.

3.4 Discussion

Without any manipulations, it could be found from original data points that B_{cr}'s effect on $\Delta\Sigma^{cr}$ is much greater than others'. As shown in Figure 3.6. There is an apparent relation between $\Delta\Sigma^{cr}$ and B_{cr} while other parameters introduce small changes based on this relation.

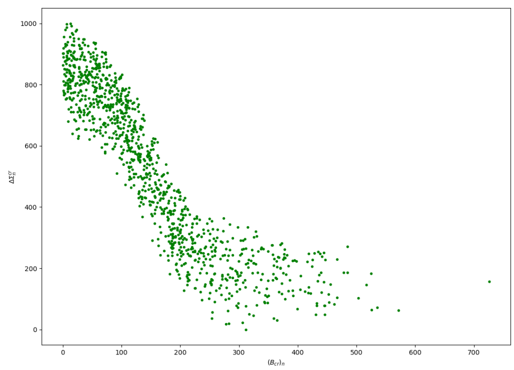
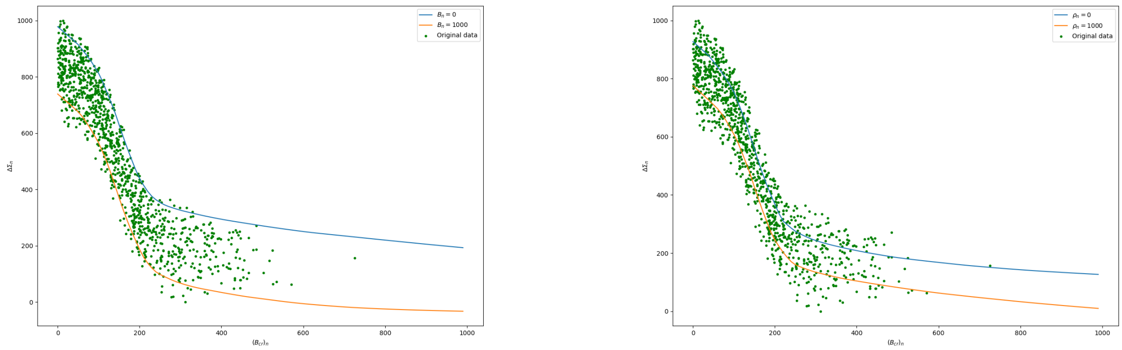


Figure 3.6: Data points

To study how much C_B or ρ could effect $\Delta\Sigma^{cr}$, we use the model trained to draw $\Delta\Sigma^{cr}$ as a function of B_{cr} in different conditions (These are lines that take B_{cr} as x axis with specific $C_B,\ \rho$ values.). As shown in Fig 3.7.

These figures show that no matter the value of C_B or ρ, $\Delta\Sigma^{cr}$ drop with the same tendency as B_{cr} increases. The correlation between the effect of burnup of control rods and born con-

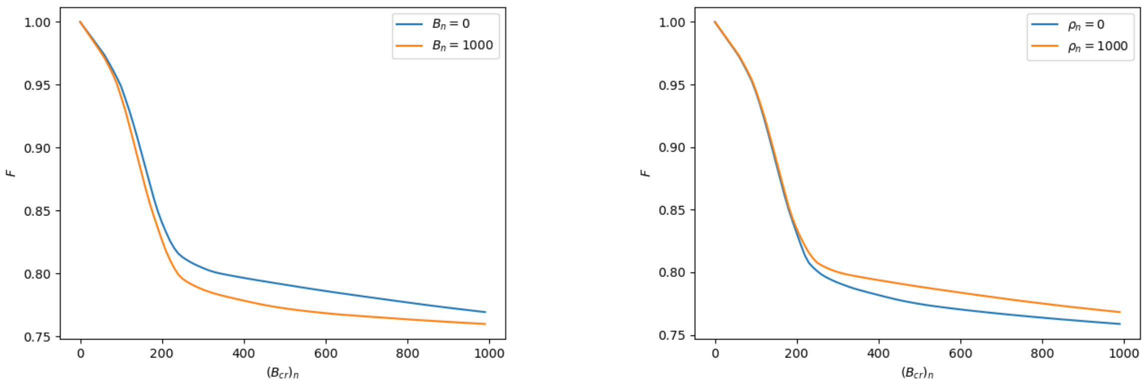


(a) Boron concentration's effect

(b) Moderator density's effect

Figure 3.7: $\Delta\Sigma^{cr}$ as a function of B_{cr}, solid lines are predictions of the model

centration or water density is not clear. Note that this is not the relation between $\Delta\Sigma^{cr}$ and C_B or ρ but the relation between F (defined in section 2.1 in equation 2.3 and 2.2) and C_B or ρ. The effect of the **burnup** of control rods is also related to C_B and ρ. If we calculate the burnup correction factor F we could see that the effect of burnup of control rods is indeed related to C_B and ρ, as shown in figure 3.8, especially for born concentration at high burnup of control rods.



(a) Boron concentration's effect

(b) Moderator density's effect

Figure 3.8: F as a function of B_{cr}

Conclusion

A relatively ease-to-access quantification of the burnup of control rods is proposed with verifications done in a typical PWR fuel assembly. A DNN model is used to predict the change in fuel assembly's macroscopic hot neutron absorption cross section. For further researches, we could try to apply BNN (Bayesian neuron network) which could provide error estimation on the predictions. Most importantly, a method of introducing burnup of control rods into reactor core simulation softwares is set up:

1. Build fuel assembly geometry in Monte Carlo simulation softwares.
2. Perform burnup calculations and track atom density of nuclides in control rods.
3. Calculate k (defined in equation 2.7).
4. Use k to calculate B_{cr} and link atom densities to B_{cr} to generate material cards.
5. Collect data using scripts like shown in section 2.2.4.
6. Normalize data and train DNN model.
7. Integrate trained model to the software or use the model to prepare a table for interpolation.

Many courses in this stage served well in this stage, especially the one where we learned TRIPOLI (a software similar to SERPENT). Some basic capabilities, like working in Linux, writing Python scripts and MATLAB scripts, that are self-studied during many projects in IF-CEN are also very important and, in fact, necessary. Besides, other courses providing basic physics knowledge on the subject are also indispensable like nuclear reactor physics, neutron physics.

After this stage, I find great interests in the domain of Artificial Intelligence. Its capability is impressive and its structure is fascinating. If possible, I would like to find researches projects relating to this domain, especially the application of deep neural network. It is confirmed that I prefer coding and simulations than experiments.

Annex

5.1 Logbook

Table 5.1: Logbook

Date	**Works**
7/1 - 7/3	Study of SERPENT and preparation of model's geometry
7/3 - 7/5	Preparation of model's materials and excel files to calculate different atom densities.
7/5 - 7/8	Calculation of a simple assembly's burnup for testing, compilation of a version of SERPENT that could draw geometry to .png files.
7/8 - 7/10	Tracking of atom densities of control rods, preparation of MATLAB scripts to read atom densities.
7/10 - 7/14	Quantification of burnup of control rods using hot neutron flux in control rods. Study of the relation between $\Delta\Sigma^{cr}$ and $\int_T \phi_h dt$.
7/14 - 7/17	Quantification of burnup of control rods using formula of B_{cr}, deduction and calculation of k.
7/17 - 7/23	Installation and study of TensorFlow.
7/23 - 8/4	Quantification of burnup of control rods using assembly average neuron flux, regression of new k and verification.
8/4 - 8/7	Preparation of Python scripts of data acquisition.
8/7 - 8/19	Several times of (data acquisition - train - evaluation) and analyzation of results.
8/19 - 8/21	Preparation of report.

5.2 Amazement report

In this stage of two months, I find that the relation between colleagues in the office not as formal as I imagined. I didn't notice any problem of corruption but still when there are some office-wide works (like fetching launch) we avoid letting high level people do the work. There are some institute-wide dinners where people should participate if they what to be sociable. However, I managed to avoid one. I heard that in some governmental organizations this kind of dinners are inevitable and corruption is very serious.

I'm a little astonished that the canteen in the university is better than the canteen here. Perhaps because of the epidemic, there are few choices and only very specific dishes can be eaten inside the canteen.

All the computers distributed by the enterprise could not connect to Internet, and it's very difficult to install softwares. Same for the servers that I used to do the simulations. Although I understand this is for the information security, it's still quite annoying the reduces the efficiency of coding. In my case, many work are done in my laptop and copied to enterprise's computers. (We cannot copy anything from enterprise's computers.)

If a student studies normally in IFCEN, he should be able to code with C++, Python and use Linux servers without any problems. These capabilities are very important in many aspects of work because many jobs require direct application of these capacities. In addition, a solid knowledge of physics (chemistry) is also very important. It helps understand the problems quickly and propose various types of possibilities and solutions. In this stage, the software used, SERPENT is very similar to the software we've studied in IFCEN TRIPOLI. In fact, I see no other differences except grammar of input cards. Monte Carlo simulation softwares are almost all like this and once you've learned how to use one of them, it's very easy to study others.

5.3 Reception service organization chart

Figure 5.1: Organization chart of reception service, the green block is where the stage took place.