English

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[http://research.ncku.edu.tw/re/articles/e/20170303/1.html]

Emotion Recognition of Affective Speech Based on Multiple Classifiers Using Acoustic-Prosodic Information and Semantic Labels

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【105 Outstanding Research Award】Special Issue

Speech is one of the most fundamental and natural communication means of human beings. With the exponential growth in available computing power and significant progress in speech technologies, spoken dialogue systems (SDS) have been successfully applied to several domains. However, the applications of SDSs are still limited to simple informational dialog systems, such as navigation systems, air travel information system, etc. [1][2]. To enable more complex applications (e.g. home nursing [3] educational/tutoring, and chatting [4]), new capabilities, such as affective interaction, are needed. However, to achieve the goal of affective interaction via speech, several problems in speech technologies, including low accuracy in recognition of highly affective speech and lack of affect-related common sense and basic knowledge, still exist. This work presents an approach to emotion recognition of affective speech based on multiple classifiers using acoustic-prosodic information (AP) and semantic labels (SLs). For AP-based recognition, acoustic and prosodic features including spectrum-, formant-, and pitch-related features are extracted from the detected emotional salient segments of the input speech. Three types of models Gaussian Mixture Models (GMMs), Support Vector Models (SVMs), and Multilayer Perceptrons (MLPs) are adopted as the base-level classifiers. A Meta Decision Tree (MDT) is then employed for classifier fusion to obtain the AP-based emotion recognition confidence. For SL-based recognition, semantic labels derived from an existing Chinese knowledge base called HowNet are used to automatically extract Emotion Association Rules (EARs) from the recognized word sequence of the affective speech. The maximum entropy model (MaxEnt) is thereafter utilized to characterize the relationship between emotional states and EARs for emotion recognition. Finally, a weighted product fusion method is used to integrate the AP-based and SL-based recognition results for final emotion decision.

Figure 1 illustrates the block diagram of the training and testing procedures for AP- and, SL-based emotion recognition. For AP-based approach, emotional salient segments (ESS) are firstly detected from the input speech. Acoustic and prosodic features including spectrum-, formant-, and pitch-related features are extracted from the detected emotional salient segments and used to construct the GMM-based, SVM-based, and MLP-based base-level classifiers. The MDT is then employed to combine the three classifiers by selecting the most promising classifier for AP-based emotion recognition. On the other hand, the word sequence recognized by a speech recognizer is used in SL-based emotion recognition. The semantic labels of the word sequence derived from an existing Chinese knowledge base called the HowNet [5] are extracted and then a text-based mining approach is employed to mine the Emotion Association Rules (EARs) of the word sequence. Next, the MaxEnt model [6] is employed to characterize the relation between emotional states and EARs and output the emotion recognition result. Finally, the outputs from the above two recognizers are integrated using a weighted product fusion method to determine the final emotional state. Furthermore, in order to investigate the effect of individual personality characteristic, the personality trait obtained from Eysenck Personality Questionnaire (EPQ) for a specific speaker

is considered for personalized emotion recognition.

For evaluation, 2,033 utterances for four emotional states (Neutral, Happy, Angry, and Sad) are collected. The evaluation results are shown in Table 1. According to the result based on EPQ, speaker A is an extrovert and the recognition performance of the corresponding emotions - happy and angry emotion which have stronger expression was improved. For speaker B who is neither extrovert nor introvert, the difference of the evaluation results is small. Besides this evaluation, the subjects were satisfied with the fine-tuned system after they tested this system again. The evaluation of the proposed approach proved that the proposed approach can work well on the emotion recognition task. In summary, the average recognition accuracy of this system can achieve 85.79% considering personality trait. The results confirm the effectiveness of the proposed approach.

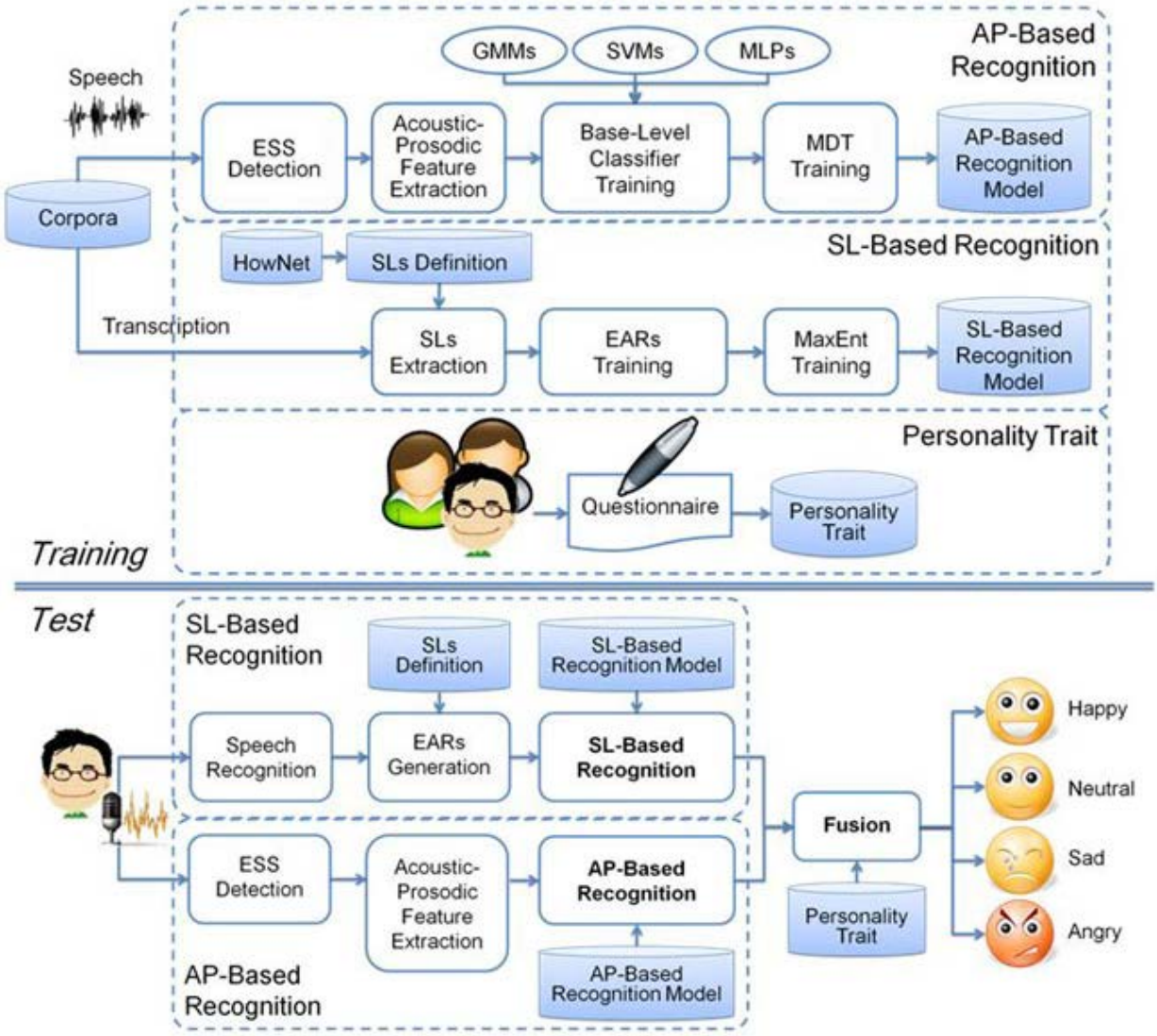

Figure 1: An overview of training and testing flowchart of the acoustic-prosodic information-based recognition, the semantic label-based recognition and the personality trait

Table 1: Evaluation results of AP-based and SL-based emotion recognition with personality trait

	MDT+MaxEnt (λ_{AP} = 0.4) (Accuracy %)				
	Neutral	Happy	Sad	Angry	Average
Speaker A	75.80%	85.97%	83.35%	87.81%	83.23%
Speaker B	80.40%	81.61%	88.49%	84.93%	83.86%
Coupus B	78.10%	83.79%	85.92%	86.37%	83.55%
	Proposed (MDT+MaxEnt+PT) (Accuracy %)				
	Neutral	Happy	Sad	Angry	Average
Speaker A	76.30%	88.79%	83.17%	89.91%	84.54%
Speaker B	86.48%	84.99%	91.49%	85.17%	87.03%
Coupus B	81.39%	86.89%	87.33%	87.54%	85.79%

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English

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Effects of the RGD loop and C-terminus of rhodostomin on regulating integrin αIIbβ3 recognition.

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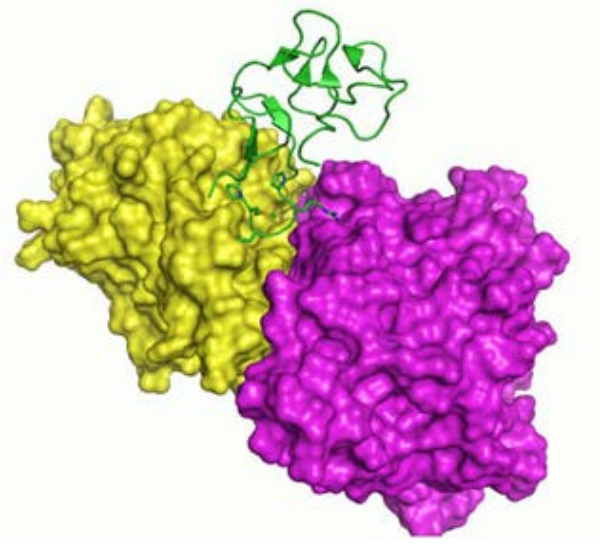
【105 Outstanding Research Award】Special Issue

Integrins are αβ heterodimeric receptors that are expressed on virtual all cells with adhesive capacity. They are involved in many common diseases including neoplasia, tumor metastasis, immune dysfunction, ischemia-reperfusion injury, viral infections, osteoporosis, and coagulopathies. Disintegrins are a family of integrin inhibitors found in snake venoms that are potent integrin inhibitors. Our studies have shown that alternations in RGD loop and the C-terminal region of these disintegrins affect their binding specificities and affinities. Rhodostomin (Rho) is a snake venom protein isolated from *Calloselasma rhodostoma*. Rho is a disintegrin that inhibits platelet aggregation by blocking the binding of fibrinogen to the integrin $\alpha_{IIb}\beta_3$ of platelets. In our study, we have successfully expressed Rho in *P. pastoris* and showed that Rho possesses the same function and structure as native protein. We also used NMR spectroscopy to determine 3D structure of rhodostomin and designed a potent and selective anti-platelet agent.



3D structure of the disintegrin/integrin complex

English

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The value of teaching and contribution of industry-university cooperative research for 40 years

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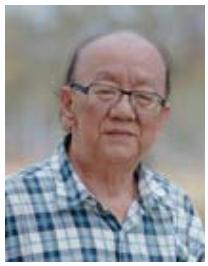
【105 Outstanding Research Award】Special Issue



In Taiwan, petroleum industry is facing huge outer threats from China and sophisticate of global industrial technology, we have to develop functional materials and products which are provided with high-value character and special grade. The development must depends on tripartite cooperation of industry, school and research unit. For many years, I am devoted to explore the industrial needs, supply and demand link of industrial technology, creation and transfer of innovational knowledge. My research group has developed many core technology and new materials which are satisfied with industrial field. We own major key techniques, such as wet-mill dispersion, new electrospinning equipment and skill, living free radical polymerization, plasma equipment and modification, fresh nickel catalyst study and preparation, one-dimensional magnetic nickel wires synthesis, and nanoparticles preparation. These techniques have applied in related fields and products preparation extensively and give assistance on industrial promotion and development. For recent years, concepts of low-carbon life and circular economy are rising, my group also pays close attention to energy and environmental materials, including catalyst preparation of hydrogenation, manufacture for converting CO/CO_2 to C_1~C_3 alkanes, change biodegradability of benzene ring structure compounds. Furthermore, in south of Taiwan, I have set up an organization, called “Huizhiclub-a platform for industrial communication of chemical engineering about creating high-value materials” (http://huizhiclub.che.ncku.edu.tw/) by integrating National Cheng Kung University, Industrial Technology Research Institute(ITRI) and mastered scholars. The goal and propose of the club is to help industries solving difficulties and problems on techniques upgrading and development of products, learn new knowledge and understand the trend about the market and the world by holding discussion seminar on regular. The club also provides professional instruments for analysis and detection to train mastered people and create chances of industry-university cooperative research projects.

Figure 1. Core technology and application on related industry of my research group

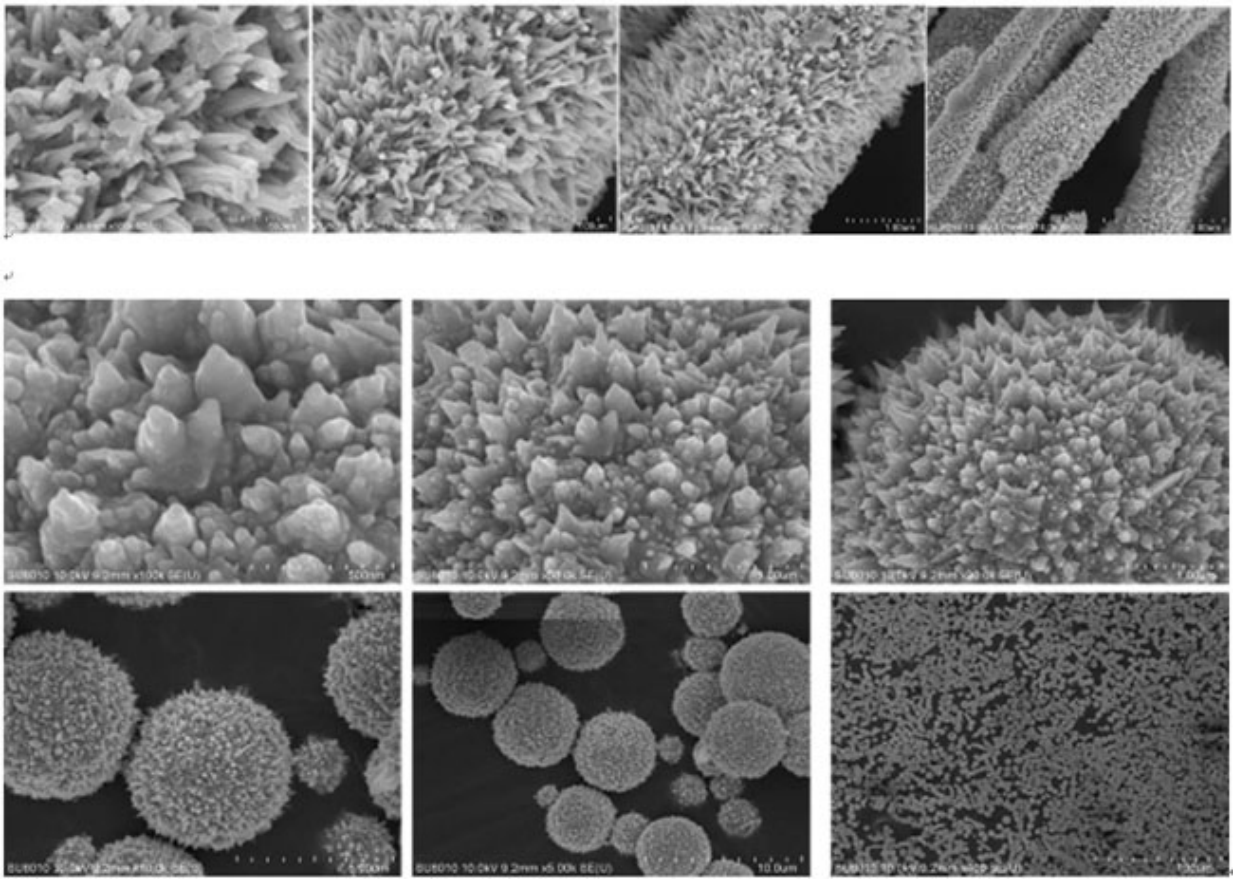


Figure 2. Catalyst for hydrogenation

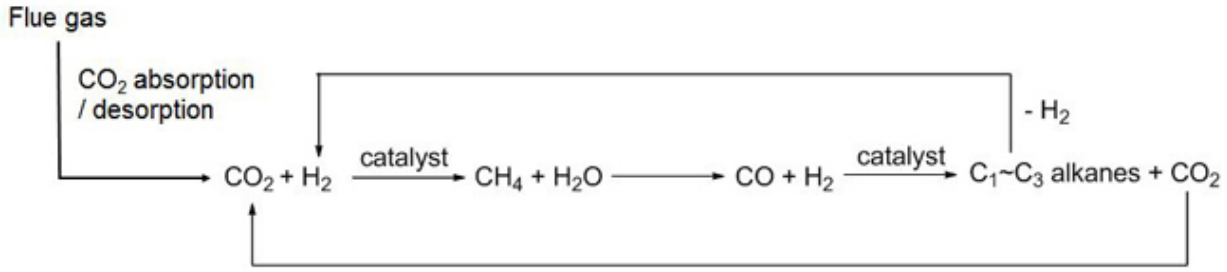


Figure 3. Manufacture of carbon cycle

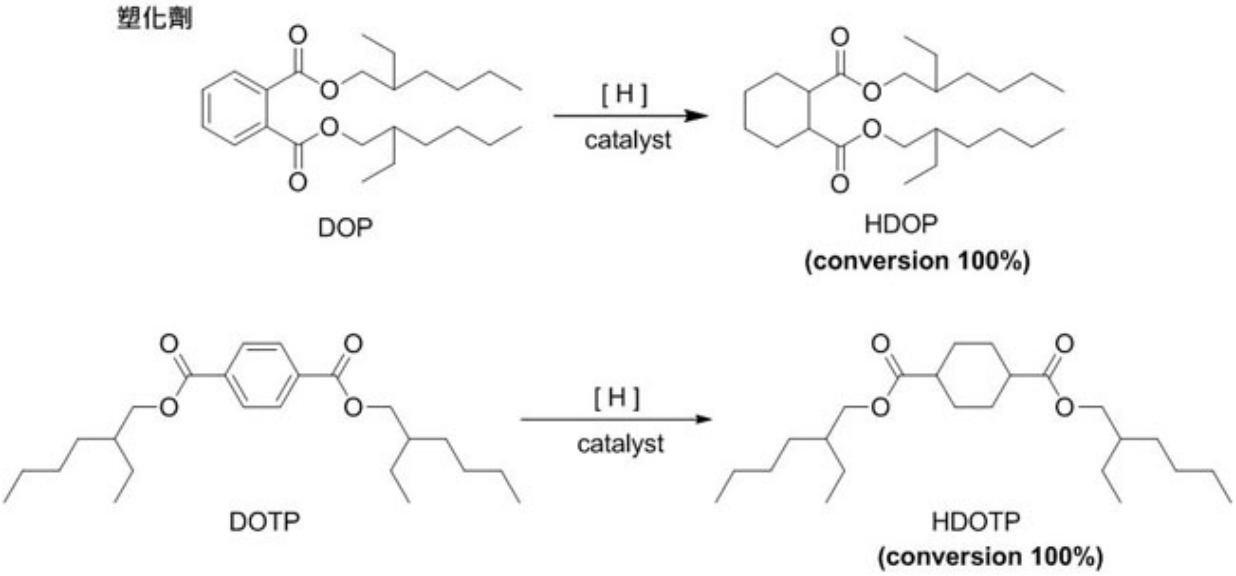


Figure 4.Change biodegradability of benzene ring structure compounds

English

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What can a chemist do in nanomedicine?

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【105 Outstanding Research Award】Special Issue

Distinguished Professor Chen-Sheng Yeh has devoted himself to develop nanomaterials and the related nanotechnology since he was employed as a faculty in Department of Chemistry, National Cheng Kung University in 1995. Research has focused on the nano-structural synthesis and biomedical applications of nanomaterials in cancer therapy and imaging diagnostics. Prof. Yeh's group that is one of very few laboratories in Department of Chemistry in Taiwan's Universities has the capability to conduct *in vivo* experiments with the established tumor models in mice.

Research includes five different categories:

(1) Development of synthetic methodology for novel nanomedicine materials: (a) Synthesis of monodispersed nanomaterials using thermal decomposition or wet chemistry preparation Hollow or porous nanomaterials by template method;(c) Highly biocompatible polymeric nanomaterials with size tunable property by self-assembly method; (d) With advanced nano-synthesis technology and unique design, we can combine diverse synthesis methods to construct the novel structural nanomaterials with multi-function.

(2) Nanoparticles as imaging contrast agents for cancer diagnosis: development of nanomaterials as magnetic resonance imaging (MRI) and fluorescence contrast agents.

(3) Nanomaterials with thermal effect for cancer therapy: Due to the increasing demand for emerging anti-cancer drugs, the nanomaterials with photothermal effect have shown their promising in cancer therapy where they could decrease the risk of normal cells damage under cancer treatments.

(4) Fabrication of multifunctional nanomaterials for killing cancer cells by photodynamic or photothermal treatments, and combined with contrast imaging capability for MRI and optical imaging:

(5) Near-infrared light triggered nanocarriers for cancer treatments: Due to the good penetration to tissue for near-infrared light, several kinds of nanoparticles are developed to be sensitive to the near-infrared light for biomedical applications.

In recent 5 years, Prof. Yeh has published 36 SCI papers including 10 papers with IF > 10. Three papers have been selected by the top-tier journals as cover (Chem. Soc. Rev.), inside front cover (Adv. Funct. Mater.) and back cover (Adv. Mater.). His research has been in the cutting edge in the field of nanomedicine and has attracted significant attraction with high citation;

(1) Ranked as top 1% cited author in Taiwan in (Thomson Reuters) Essential Science Indicators (ESI) in material science field (2012).

(2) List in the top 10% of most highly cited authors in the general chemistry portfolio of journals of Royal Society of Chemistry, United Kingdom (2016).

English

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Challenge of Long-Term Indigenous Development of Critical Systems – Development of Hydrogen Peroxide Satellite Reactive Control System (RCS) as an Example

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AIAA J. of Propulsion and Power, Vol. 23, No. 6, pp.1313-1320 (2007).
AIAA 2011-5693, 47th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit (2011).

【105 Outstanding Research Award】Special Issue

I. Challenge of Long-Term Indigenous Development of Critical Systems

In the current atypical engineering research and development environment in Taiwan, researchers should be encouraged to look very carefully and honestly of the current national engineering capability. What this country needs most is not the number of paper publication of most advanced technology, but those critical materials, techniques, and systems that subject to export license controls. Long-term indigenous development is the key to successful breakthrough of these limitations and controls. Export licenses usually control a series of critical materials, parts, and systems in sequence. The key point is that these critical materials and techniques lead to high-precision and high-quality system with direct impact on promotion of industrial and technology level. Therefore, sustained long-term in-depth research and development step by step from materials, techniques to systems with careful examination and verification tests is the true spirit of long-term indigenous development. The challenge of long-term indigenous development lies in the integrations of these difficult factors: long-term and sustained devotion and sacrifice of the researcher, the research environment of advanced major test facilities and instrumentations with sufficient technology support of experienced technicians, and long-term continuous (usually more than 10 years) research funding support from the government or agents. These challenges are difficult to overcome for the current university and government systems, and are highly concerned topics to be reconsidered.

Ⅱ. Long-term development hydrogen peroxide satellite reactive control system (RCS)

Hydrogen peroxide in aerospace applications can be dated back as early as WWII [1-2] and recently attracted extensive revised research attention due to the prevailing of “green” propulsion concept [3-5] .Take the long-term devotion of our research team to the indigenous development of hydrogen peroxide satellite reactive control system (RCS) as an example. Thanks to the advanced major test facilities and instrumentations and the sufficient technology support of experienced technicians provided by NCKU Aerospace Science and Technology Research Center (ASTRC) since the establishment of NCKU Institute of Aeronautics and Astronautics (IAA) in 1983, and more importantly, the long-term continuous (usually more than 10 years) research funding support from National Space Organization (NSPO) and National Chung-Shan Institute of Science and Technology (NCSIST) and funding for full-time research manpower from Ministry of Science and Technology (MOST), the goal of long-term indigenous development of hydrogen peroxide satellite RCS is successfully achieved.

Hydrazine and its catalyst have long been used as RCS for satellites. However, in view of the extreme toxic hazard and export license control of hydrazine and catalyst and after careful evaluation we have chosen hydrogen

peroxide and its catalyst as the candidate for our indigenous development for satellite RCS. Although high-concentration hydrogen peroxide (or called high-test peroxide, HTP) for propulsion is still subject to export license control and without local supplier, we still decided to choose the “green” HTP as the target critical material for indigenous development. After about three years of investigation and study, we have set up the facility and technical procedure to produce high-test propulsion grade hydrogen peroxide (85% and up of concentration) [6] . We are the sole research team that owns this technique and facility in Taiwan and this technique and facility have been transferred to NSPO under contract. Further development was devoted to the study of an innovative high-efficiency, stable and long-durability catalyst and composite catalyst bed design for satellite RCS [7] , as shown conceptually and schematically in Fig. 1.

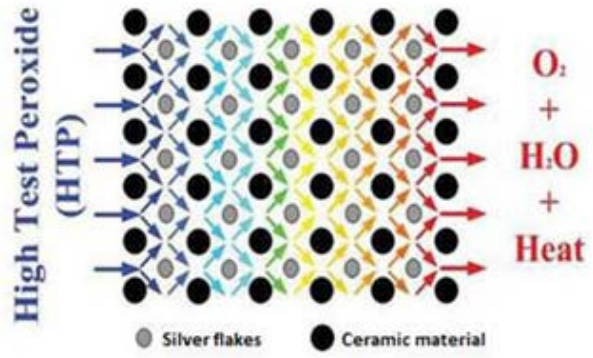

Fig. 1 Conceptual design of the composite catalyst bed for decomposition of high-test hydrogen peroxide

The high-concentration HTP and high-efficiency catalyst bed techniques were applied in further development of a pair of 1-lb hydrogen micro-thrusters. The thruster system was used as the propulsion payload for high-altitude tests in the 8th National Sounding Rocket program and was successfully launched to an altitude more than 270 km in 2013. The thruster and the propulsion payload system is shown in Fig. 2.

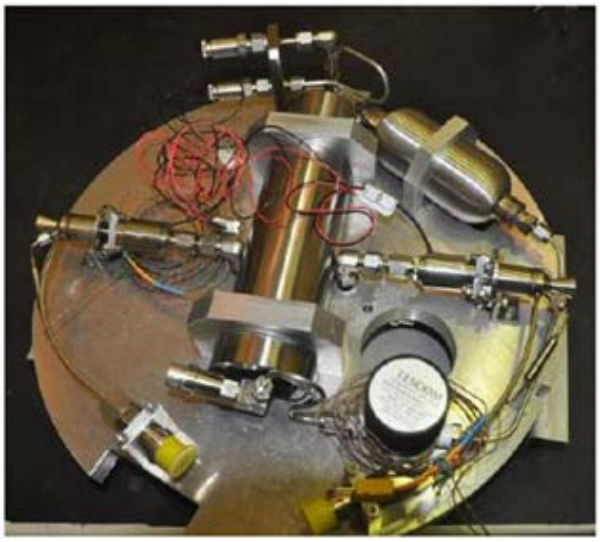

Fig. 2 Photograph of the HTP thruster system for flight tests in the 8th National Sounding Rocket Program

Later, our team became the first university research team to officially sign up a long-term (7 years) research contract with NSPO to develop and to transfer technology for an 1N RCS system. Through a series of careful hot-fire, ground and vacuum tests and verifications, the indigenous RCS system is scheduled to be used in the National Formosa Satellite #7 to be launched in 2018. The long-term indigenous development of the “green” satellite RCS proves to have direct impact on up-grading our space technology and space industry as well as on enhancing our precision defense technology.

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English

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Breakdown of Bose-Einstein Distribution in Photonic Crystals

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Scientific Reports, Vol. 5, 9423 (2015)

Photonic band gap (PBG) structures in photonic crystals (PCs) together with the characteristic dispersion properties have stimulated considerable interest in the study of fundamental photonic science and also in the development of new photonic technology[1]. The most significant new features induced by the PBG are the inhibition of atom spontaneous emission and the localization of light[2]. This provides the opportunity to control and manipulate light for photonic information technology. Practically, understanding photonic quantum dynamics at finite temperature is important for the development of all-optical circuits incorporating cavities and PBG waveguides embedded in PCs in the microwave regime.

We investigate micro/nano cavity photonics in PCs at finite temperature. Due to PBG-induced localized long-lived non-Markovian photon dynamics[3], we find that cavity photons in PCs do not obey Bose-Einstein statistical distribution. Within the PBG region and also in the vicinity of the PBE, cavity photons combine the nontrivial non-Markovian dissipations with thermal fluctuations together to form photon states that can memorize the initial cavity state information. As a result, Bose-Einstein statistical distribution for photons is completely broken down in these regimes, even though the photonic thermal energy is larger or much larger than the cavity detuning energy. This conclusion is generally valid for various photonic band gap structures in PCs. For the 1D and 2D PCs, the breakdown of Bose-Einstein distribution leads to a crossover from equilibrium to nonequilibrium cavity steady states, while for 3D PCs with an anisotropic DOS, the breakdown of Bose-Einstein distribution corresponds to a critical transition rather than a crossover. No matter whether it is a crossover or a critical transition, the breakdown of Bose-Einstein distribution is a consequence of localization photons due to the presence of PBG structures in PCs. Therefore the conclusion is also valid for other nanomaterials with band gap structures. It could provide a hitherto unexplored challenge on photon statistics.

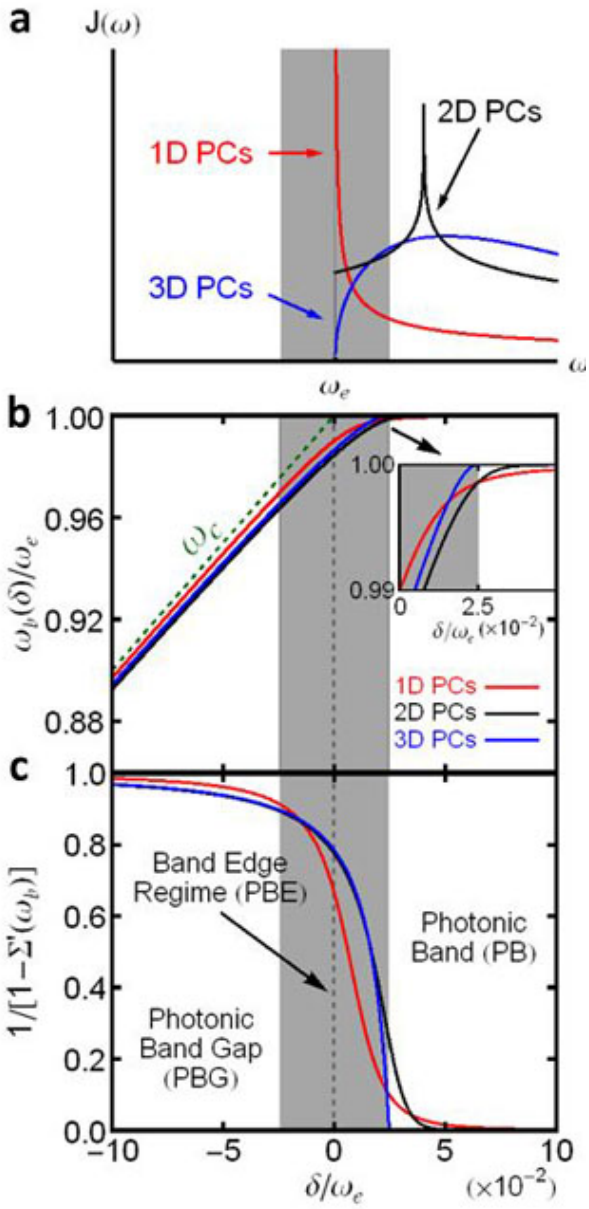

Figure 1. Band structures of photonic crystals and localized photon modes. (a) Spectral densities for different DOS of 1D, 2D and 3D PCs are plotted respectively in the vicinity of photonic band edge ω_e; (b) The corresponding localized photon mode frequency ω_b as a function of the detuning $\delta=\omega_e-\omega_e$ and (c) The corresponding localized photon mode amplitudes.

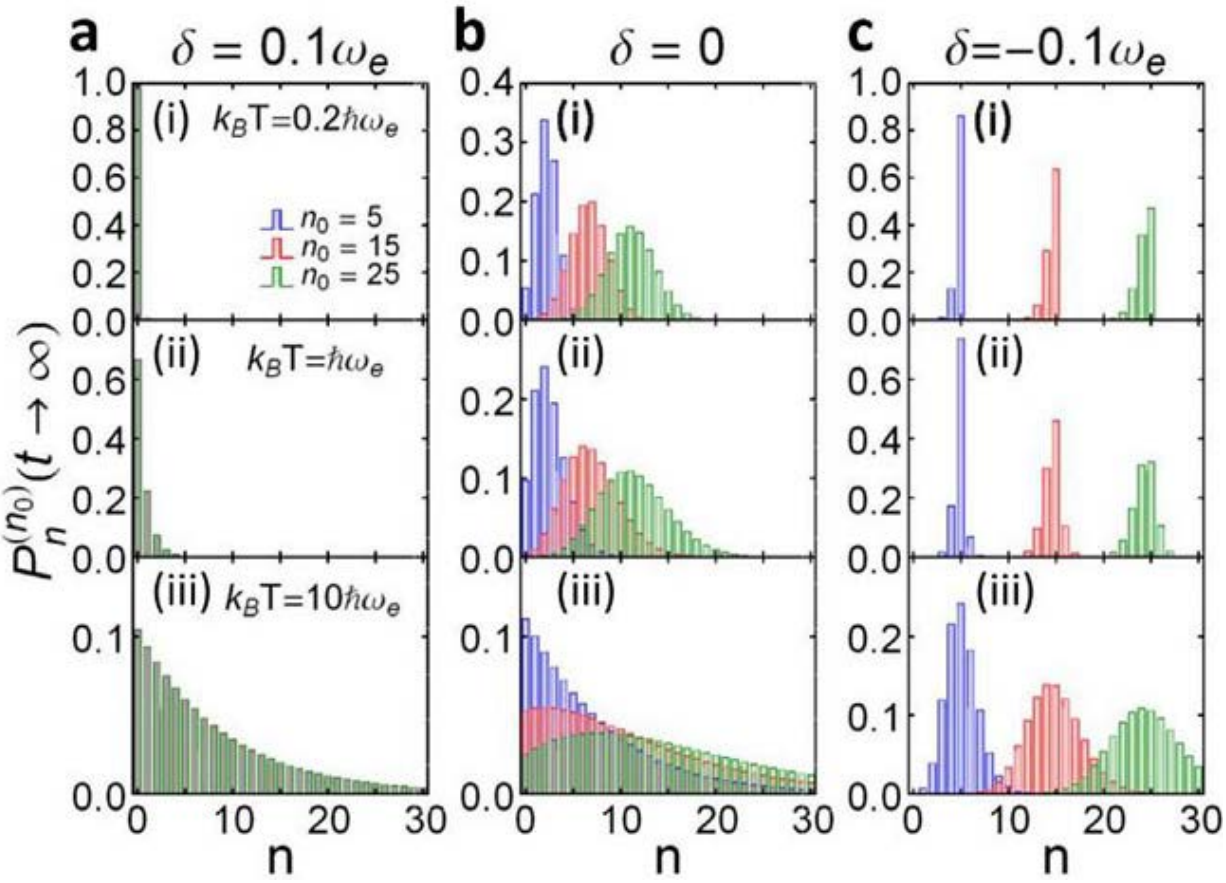

Figure 2. The steady-state cavity photon distribution, $P_n^{(n_0)}(t \to \infty)$ for different initial Fock states $|n_0\rangle$, n_0=5, 15 and 25 (in terms of different colors); with different detuning δ: (a) δ=0.1ω_e, (b) δ= 0, and (c) δ= -0.1ω_e; and different temperatures T of the photonic crystals: (i) $k_BT \sim 0.2\ \omega_e$, (ii) $k_BT \sim 1\ \omega_e$, and (iii) $k_BT \sim 10\ \omega_e$, as given in the figure.

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English

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Evolution of breaking waves on sloping beaches

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Coastal Engineering

For the shoaling process of wave propagating on a gently sloping bottom, authors have systematically discussed on a single progressive wave; however, wave–wave interaction usually occurs and is important in ocean. Especially the evolution of shortwave riding on long wave will need to be further gone into.

We provide an analytic solution for two progressive waves propagating on a sloping bottom, which the writers believe was not treated appropriately in previous available reports. In explicit form both the velocity potential and the surface elevation are expanded as a three-parameter function of rendering the two wave ordering parameter ε1, ε2 and the bottom slope α perturbed to the third order in the Eulerian coordinate system. The results possess the configuration of the general solution; therefore, it can degenerate into a single propagating wave on sloping beach, and wave–wave interaction in uniform depth. We present that the ratio of wave number ki/λi0 increases with the decrease in dimensionless water depth λi0h. It also relates to the bottom slope and incident wave steepness. That is, increasing bottom slope or decreasing incident wave steepness increases the ratio. The angular frequency is also affected by another propagating wave. Decreasing water depth or increasing the ratio λ10/λ20 will enhance the effect mentioned above. Our solutions included the wave–wave interaction, wave shoaling, nonlinearity, and the effect of bottom slope. Those were observed by means of the discussion of the free-surface displacement.

The resonance occurring in specified water depth between the ratio$\lambda_{10}/\lambda_{20} \approx 2.3$ and $\lambda_{10}/\lambda_{20} = 4$ can be interpreted as being due to the wave–wave interaction. However, the singularity of free-surface displacement under the resonant conditions will be further studied in the future.

English

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A multi-index hybrid trie for IP lookup and updates

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High-performance routers require high-speed IP address lookup to achieve wire-speed packet forwarding. This study proposes a new data structure, the Multi-Index Hybrid Trie (MIHT), for dynamic router table designs. This data structure was constructed by combining the useful characteristics of the B^+ tree and priority trie. Figure 1 is an example.

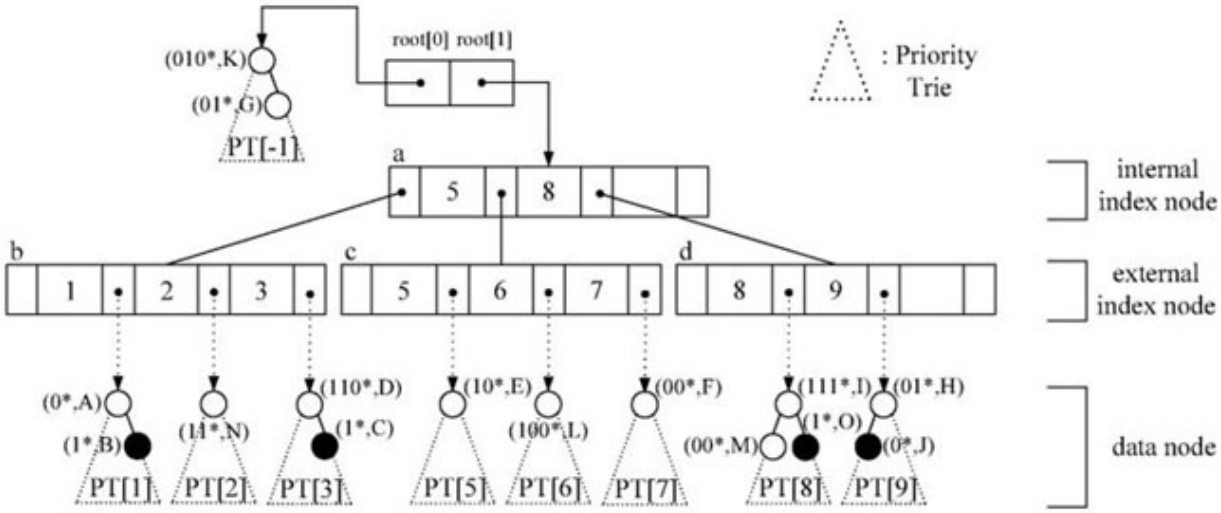

Figure 1. (4,4)-MIHT

IP lookup operations can be performed efficiently by associating each prefix with a key value in the MIHT. Furthermore, because the required tree height and number of prefixes were reduced, dynamic router table operations were performed efficiently using the MIHT. To reduce the memory requirement, each prefix stored its corresponding suffix in a node of the MIHT, rather than storing a full prefix. Experiments using IPv4 and IPv6 routing databases indicated that the proposed data structure has efficient memory usage and performs well for lookup, insertion, deletion operations. This study reports the results of the experiments performed to compare the proposed data structure with other structures using the benchmark IPv4 and IPv6 prefix databases AS1221, AS4637, AS6447, AS65000, AS1221*, and AS6447* with 407,067, 219,581, 417,995, 406,973, 12,155, and 12,278 prefixes, respectively, where AS1221* and AS6447* are IPv6 BGP routing tables. Tables 1-3 are the performance comparison for the various data structures.

Table 1. Average Tree Heights and Storage Comparisons of the Various Data Structures

Data Structure	Avg. Tree Height				Storage (KB)			
	AS1221	AS4637	AS6447	AS65000	AS1221	AS4637	AS6447	AS65000
Binary Trie	32	32	32	32	11,519	6,731	11,870	11,513
LC-Trie	23	21	25	23	13,772	8,266	14,011	13,762
Prefix Tree	29	29	32	29	6,360	3,430	6,531	6,358
Priority Trie	28	27	32	29	6,360	3,430	6,531	6,358
DTBM	10	10	10	10	25,291	14,506	25,997	25,285
4-MPT	11	10	10	10	21,484	11,391	22,049	21,501
4-PCMST	10.08	9.72	10.13	10.04	22,172	12,463	23,051	22,043
(16,16)-MIHT	8.04	7.66	8.07	8.04	6,883	3,778	7,064	6,881
(16,16)-PMIHT	4.11	3.47	4.16	4.11	6,875	3,776	7,056	6,873

Table 2. Performance Comparisons for Lookup for the Various Data Structures

Data Structure	Avg. Lookup Time (# of Clock Cycles)				Avg. # of Memory Accesses			
	AS1221	AS4637	AS6447	AS65000	AS1221	AS4637	AS6447	AS65000
Binary Trie	2,990	2,684	3,018	3,000	23.56	23.40	23.59	23.56
LC-Trie	3,006	2,857	3,020	3,015	9.25	9.75	9.26	9.24
Prefix Tree	3,206	2,793	3,215	3,206	21.71	21.31	21.72	21.71
Priority Trie	2,864	2,481	2,872	2,862	20.09	19.65	20.09	20.09
DTBM	2,094	1,912	2,091	2,114	8.34	8.29	8.35	8.34
4-MPT	2,878	2,509	2,850	2,866	15.69	14.71	15.61	15.70
4-PCMST	2,012	1,805	2,112	2,151	10.16	9.52	9.57	9.16
(16,16)-MIHT	2,222	1,920	2,227	2,221	9.51	9.17	9.51	9.51
(16,16)-PMIHT	1,954	1,657	1,935	1,953	8.31	8.05	8.30	8.30

Table 3. Performance Comparison for Updating for the Various Data Structures

Data Structure	Avg. Update Time (# of Clock Cycles)				Avg. # of Memory Accesses			
	AS1221	AS4637	AS6447	AS65000	AS1221	AS4637	AS6447	AS65000
Binary Trie	4,138	4,021	4,216	4,181	26.55	26.70	26.59	26.54
Prefix Tree	2,445	2,395	2,426	2,438	20.87	20.33	20.77	20.85
Priority Trie	3,834	3,830	3,831	3,849	21.42	21.00	21.43	21.42
DTBM	2,755	2,705	2,749	2,754	8.90	8.91	8.91	8.90
4-MPT	2,144	2,419	2,178	2,277	6.24	6.26	6.21	6.24
4-PCMST	1,345	1,517	1,079	1,153	4.04	4.05	3.02	3.24
(16,16)-MIHT	1,907	1,780	1,853	1,900	8.90	8.70	8.90	8.90
(16,16)-PMIHT	1,679	1,693	1,622	1,679	7.56	7.46	7.56	7.57

English

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Social isolation-induced increased NMDA receptors in ventral hippocampus primes mice for aggressive behaviors

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Family and social support is a critical factor for physical and psychological health for human being belonged to social animal. Prolong social isolation have long-term effects on the susceptibility to subsequent stress exposure. We used the animal model of post-weaning social isolation to research the behavioral responses to acute stress in adult mice. Rodent pups were separated and singly housed in the individual cages on postnatal day 21~28 and were given free access to water and food. The social isolation-reared (SI) mice only had visual, auditory and olfactory contact with other conspecifics without any form of physical interaction with each other.

During adulthood, SI mice exhibited a higher spontaneous locomotor activity. Schizophrenic patients have the deficient prepulse inhibition (PPI) of acoustic startle reflex, which is used to assess the subject's ability to gate or filter environmental information for the integration of cognitive and sensory information. We found post-weaning social isolation also impaired the PPI of mice, indicating abnormalities of sensorimotor gating. SI mice also exhibited a higher level of despaired behavior in the forced swimming test, suggesting the depression-like phenotype. In the social interaction test, SI mice exhibited more offensive behaviors but not attack number compared with group housing (GH) mice. However, acute stress significantly exacerbated attack counts of SI mice to the intruder mice and induced higher levels of anxiety-like behavior in the open field test. These results suggested that post-weaning social isolation induced susceptibility to acute stress and exaggerated attack behavior in mice.

Moreover, SI mice exhibited an increased level of NR_{2B} subunit of NMDA receptors in the hippocampus. The NMDA receptor inhibitor or a specific NR_{2B} inhibitor was infused into hippocampus of SI mice reversed acute stress-induced exaggeration of aggressive behavior. In addition, the specific knockdown of NR_{2B} expression in the hippocampus by shRNA transfection technique significantly reduced the stress-induced attack level of SI mice. These results suggested the isolation-induced increased levels of NMDA receptors in the hippocampus may mediate the stress-induced aggression.

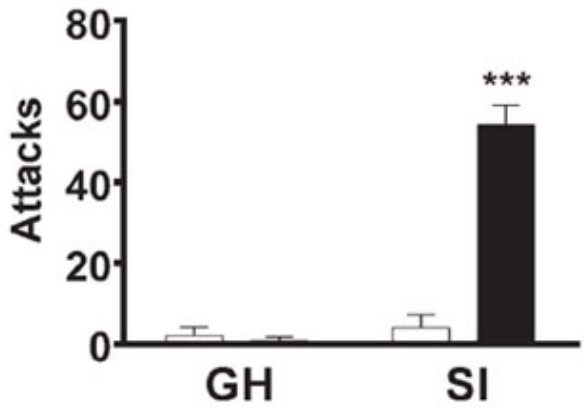

Figure 1: The socially isolated (SI) mice exaggerated attack behavior after acute stress. GH: group housing mice, SI: socially isolated mice; white bar: no stress, black bar: acute stress.

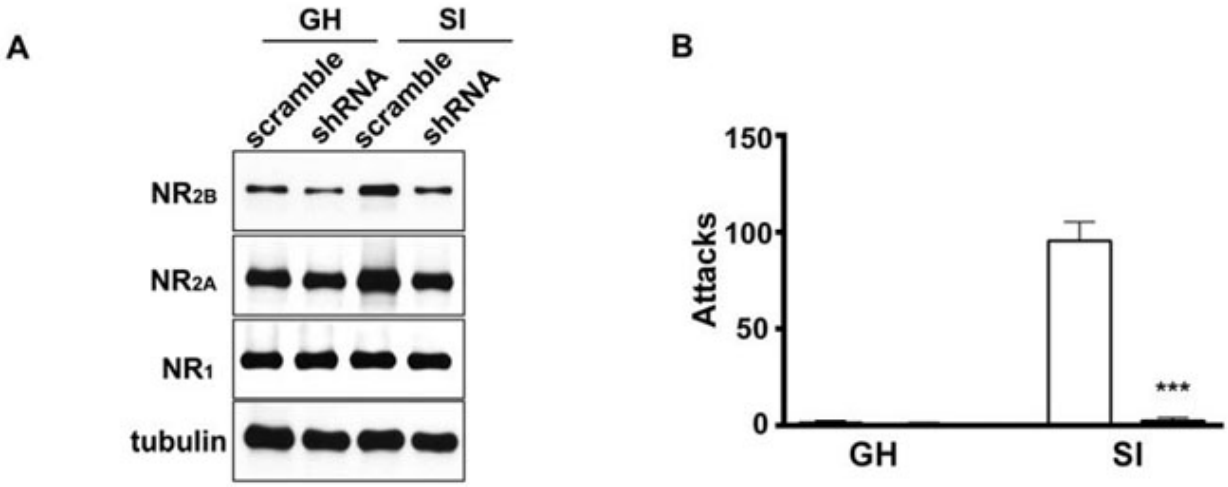

Figure 2: (A) SI mice exhibited an increased level of NR_{2B} subunit of NMDA receptors in the hippocampus. (B) The specific knockdown of NR_{2B} expression in the hippocampus by shRNA transfection technique significantly reduced the stress-induced attack level of SI mice. GH: group housing mice, SI: socially isolated mice; white bar: scramble control, black bar: NR_{2B} shRNA.